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# GRASS in Conservation in the United States



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The new generation of conservation farmers and ranchers has come to manage grasses and legumes as primary crops on a par with the conventional row crops and small grains of yesterday.

# GRASS IN CONSERVATION IN THE UNITED STATES[1]

Contents



[1] In this publication, as in the common language of farmers and ranchers, the word "grass" in its general sense includes plants of both the grass and legume families.

Hay harvest from a grassed waterway between corn and oats.

# GRASS IN SOIL AND WATER CONSERVATION

By D. A. Williams, Administrator, Soil Conservation Service

As far back as records go into civilization's dawn, grass has been a solid base for agriculture. Through the centuries it has provided most of the forage for livestock feed and cereals for man's own food.

In the United States in the past generation grass has gained new eminence as a tool in soil and water conservation. Today it occupies a dual role of production and protection in American agriculture.

The withering drought and the financial depression of the 1930's triggered an agricultural revolution that brought forth a new national program to halt soil erosion and protect renewable natural resources. With it new grassland science emerged, and new grasses and legumes for forage grow on nearly half the land area of the United States. A return of about 17 billion dollars annually comes from the livestock and poultry that eat grasses, grains, hay, and silage.

On the farms of America before 1930, grass was often looked upon as a resource of minor value. In the South and in the Great Plains, farmers grew mostly clean-tilled row crops and small grains. In most of the country, improved pastures occupied a position of minor importance.

Even where grass was seeded for hay or pasture, farmers seldom thought of using fertilizer or providing special care such as they did for cultivated crops or orchards. Legumes, such as alfalfa and the clovers, too often were planted on the poorer land and given little further attention.

In the absence of improved varieties of grasses and legumes, or of knowledge about their management and potential productivity, farmers understandably paid little attention to grass so long as good land was plentiful for cultivated crops. It was after they became aware of widespread damage from erosion that they became interested in these plants for soil conservation and as primary income-producing crops.

The drought of the early 1930's (coupled with the effects of a declining soil fertility) parched crops and grasslands in all areas of the Nation except the humid East. Winter and spring winds swept across the bared lands of the Great Plains, whipping soil into the air. These "black blizzards" imparted to the national consciousness a new sense of urgency about the menace of soil erosion.

In Congress the pleas of Dr. Hugh H. Bennett already had awakened interest in the problem. In 1929, through the Buchanan amendment, Congress provided $160,000 for the first soil erosion experiment stations to be established by the Secretary of Agriculture.

## Experimental Basis for a Program

In record time, 10 erosion experiment stations were set up across the country and were busy studying the causes and effects of erosion. This was the beginning of scientific soil and water conservation based on technical knowledge derived from experimental research.

Soon, largely through the work of these stations, a vast amount of convincing information was acquired and given to the public. More than 200,000 quantitative measurements were made of soil and water losses under different conditions of land use. It was then that grass came into its own in the United States, for scores of the experiments proved that the dense cover on the surface and the fibrous root systems in the soil produced by grasses and legumes are of superior effectiveness both in preventing erosion and maintaining productivity of farmland.

Measurements beginning 1931 showed how grass protects soil against erosion from runoff.

At the station at Guthrie, Okla., for example, it was found that more than 10 times as much water ran off an 8-percent slope planted to cotton as from land of similar type covered with bermudagrass. It, likewise, was found that the amount of soil washed was nearly 500 times as great on the cotton land as on the bermudagrass. Research results at the Clarinda, Iowa, station showed that more than five times as much water ran off a sloping cornfield as from the same kind of land in alfalfa, and the soil loss was about 180 times as great on the cornfield. Experiments at Zanesville, Ohio, revealed that runoff was more than three times, and soil loss about twice, as much from an unimproved pasture as from a pasture that had been limed, fertilized, planted to a good grass mixture and properly managed. When summed up they proved that, on the average, a covering of grass or other dense-growing vegetation is 313 times more effective in retaining soil and 6 times more effective in retaining rainfall than clean-tilled crops on the same kind of land.

In all such experiments erosion damage was found to be consistently heavier on land planted to a clean-tilled crop year after year than on land under a good rotation containing grasses and legumes. They also proved that yields of cash crops depend greatly on grass. Results in the Corn Belt revealed that the yield of corn following clover was more than 2-1/2 times as great as for continuous corn. It was here and in similar findings that the ideal expressed in such words as larger yields from fewer acres was born.

The experiment stations found too that grasses and legumes could be managed after the plants are dead so as to reduce losses of soil and water. Straw, stubble, and stalks left on or near the surface served to increase greatly the absorption of water by the soil. Proper ways of handling such residues were studied intensively in all stations and proved extremely valuable. In South Carolina, a mulch-disk method that kept much of a cover crop of rye and vetch on the surface reduced soil loss 46 percent and water loss about 50 percent, as compared with losses where the cover crop was turned under. Early results at the stations indicated that mulch tillage causes greater improvement in soil structure and more rapid increase in soil organic matter and nitrogen in the first 5 inches of soil than tillage without mulch.

Grasses for pastures, and for range forage throughout the vast West, were subjected to intensive experimentation and trial over the years at many locations, both by the Soil Conservation Service (SCS) and other agencies of the U.S. Department of Agriculture (USDA) and the States. The plants themselves, and their adaptations to soils and climate, were the primary concern, for many pastures and ranges were sadly depleted of grass cover and some had no value at all for the country's tremendous livestock industry.

Finding the best grasses and other forage plants, locating them for good production and palatability, and then testing each one for its productivity and effect on livestock's well being came next at most stations. Findings such as these from a cooperative study at the Central Plains Range Experiment Station, requiring years, had values never available before:

Yearling Herefords gained an average of 252 pounds on short-grass range stocked with 40 head per section for a 6-months season. On comparable range, overstocked at 60 head per section, the average gain was only 174 pounds. Comparable profit in 1946 was $1,807 per section for the range stocked at grazing capacity and $1,345 for the overgrazed, even though the latter produced slightly more beef. The heavy stocking resulted also in cumulative soil and forage deterioration (Chapline 1948).

After the erosion experiment stations had been functioning only 4 years, in June 1933, Congress appropriated money through the National Industrial Recovery Act for erosion-control work as a means of unemployment relief. On September 19, 1933, the Soil Erosion Service was established as a temporary agency of the U.S. Department of the Interior. This resulted in the setting up of 41 soil and water conservation projects in the Nation. Civilian Conservation Corps camps provided bases and staffs as well as the manpower for the testing of new technology in conservation on a voluntary basis by farmers and ranchers.

## The Charge to an Agency

On March 23, 1935, the Soil Erosion Service was transferred from the Department of Interior to the Department of Agriculture. It became the Soil Conservation Service, charged by Congress in Public Law 46 " to conduct surveys, investigations and research relating to the character of soil erosion and the preventive measures needed . . . To carry out preventive measures, including . . . engineering operations, methods of cultivation, the growing of vegetation and changes in the use of land . . . "

The assignment was in an uncharted field. Erosion, its character and causes, its prevention and cure, was largely unexplored. But the search began, a painstaking, relentless, world-wide search for techniques and materials that would halt the progress of erosion. It was a time of trial and error, of examination and comparison, of frustration but refusal to accept defeat--and it was a time of occasional and heartening success.

Leading in the effort were the technical forces of SCS and the other agencies of USDA, the agricultural colleges and the experiment stations, solidly reinforced by the millions of American farmers and ranchers whose own experience pointed the way to realistic solutions to many of the problems.

Out of this came the concept of the complete coordinated soil and water conservation plan, designed specifically for a given farm or ranch to combine all needed practices for maximum effectiveness. Such a plan provided for the treatment of each parcel of agricultural land according to its need for treatment and for the use of each parcel within its capability for continuing agricultural service.

Such an integrated plan was a sharp departure from the single-practice approach to soil problems that had been used by agricultural workers up to that time. The basic conservation plan, making use of combinations of practices fitted to differences in soil, continues to this day as the fundamental principle of conservation planning for farms and ranches, watersheds, and other project areas.

## Tools for the Job

Inevitably the search for the tools with which to accomplish the protection and repair of land led to grass, trees, and shrubs. Among these, grass was in the forefront.

Fortunately, research on forages, their establishment and management, and plant breeding for improved varieties had begun very early in USDA and the State experiment stations. Soil conservationists, therefore, had a valuable backlog of information when they started using these plants to meet the special requirements of soil and water conservation.

A first step in providing seed of a large number of improved range, pasture, and hay plants was the setting up of nurseries for this purpose by the Bureau of Plant Industry in 1933. Much of the work of these nurseries was devoted to the testing of grasses. In 1935, they were transferred to SCS.

In the Great Plains the need for the nurseries to collect and grow grass seed was urgent. Nurseries were first established in this region at Mandan, N. Dak., and Manhattan, Kans.

In other areas of the Nation seed-increase work was scarcely less important. Nurseries were established early at Albuquerque, N. Mex.; Americus, Ga.; Beltsville, Md.; Big Flats, N.Y.; Elsberry, Mo.; Pullman, Wash.; San Antonio, Tex.; Zanesville, Ohio; Tucson, Ariz.; Pleasanton, Calif.; and Thorsby, Ala. Others were added later; at one time there were 24 of these nurseries.

The immediate need was to obtain promising plants and to get preliminary information about their possible conservation uses and values by comparing them with common varieties. The plants tested came from both foreign and native sources. Numerous species now in common use were known 30 years ago, or less, only as native wild plants.

Any plant material that appeared to be promising in nursery rows was then studied in plots similar to small farm fields. Those considered to hold promise for soil and water conservation were tested further in outlying stations. These studies generally were in cooperation with State experiment stations, but some joint testing was done in soil conservation districts, with individual farmers, or with other agencies such as the U.S. Forest Service.

The final step was to make foundation seed stocks of the new or improved varieties available to farmers and commercial seed growers. From the first, SCS recognized that it was not the business of a Federal agency to compete with commercial producers but to serve as a source from which commercial production of tested and proved seeds could develop. As soil conservation districts spread over the country, farmer-district production of new conservation plants became an important source of seed.

Early in the development of this new interest in grass in conservation, research specialists, soil conservationists, farm-implement manufacturers, and farmers themselves, teamed up to provide growers with a variety of machines for handling the newfound crops: special grass-seed planters and fertilizer spreaders, mowers and rakes, hay balers and loaders, silage cutters and hay dryers. Improvements and innovations came periodically. These included precision drills, band-seeding attachments for fertilizer and grain drills, and heavy-duty drills for interplanting in sod.

Special hammermills and other equipment for cleaning native grass seed were developed, beginning with the 1930's. Grass seed cleaning and processing plants sprang up throughout the country. All the improved machines, each for a specific new need, have made the grass farmer's operations easier and more profitable.

Between 1944 and 1954, seed production of most of the grasses and legumes then in new demand increased to the point that farmers and ranchers for the first time could buy the seed they needed at reasonable prices.

The harvesting of native grass seed was a new local business arising out of the soil conservation program. In 1950, more than 425 million pounds of grass and legume seed was harvested in soil conservation districts alone. For many farmers, growing grass seed on cultivated land became an enterprise more profitable than growing ordinary crops such as wheat, cotton, or corn.

## An Area for Testing

In its early efforts to solve the problems of erosion control, SCS expended much of its time and resources on the critical areas of the Great Plains. The need for materials and techniques that would effectively prevent erosion and repair damaged land was acute in that region.

Some of the early efforts took place on land acquired by the Federal Government under Title III of the Bankhead-Jones Farm Tenant Act and termed "land-utilization projects." These were patchworks of submarginal farmlands that had been damaged by erosion. Many of the farms had been abandoned. They were administered first by the Bureau of Agricultural Economics, then transferred to the Soil Conservation Service in October 1938. On these projects SCS, in 1939, began a series of trials in the use of grasses that would arrest erosion and permit the damaged land to again serve in agriculture.

In these early years the effort was marked by a high percentage of failures. The experience, however, proved of tremendous value.

SCS established seed plots on many of the projects. The seed produced was used first to plant the rundown and damaged lands. Later the projects began to yield seed for use elsewhere.

## Experience on the Land

Perhaps the most important single factor in the spreading of an appreciation of grass in conservation was the experience of land owners and operators themselves in soil conservation districts. The first such district was certified on August 4, 1937, as the Brown Creek Soil Conservation District in Anson County, N.C. Under the district approach, the farmers and ranchers of the Nation began working together, assuming responsibility for the solution of their soil and water problems and receiving technical help

from the Federal Government through memorandums of understanding with the Secretary of Agriculture. The principle of applying combinations of needed soil and water conservation practices to a farm or ranch unit, including conservation cropping systems using grasses and legumes, became a focal point. The districts, with their local leadership, began exerting a strong influence on the development of useful grasses and legumes for agricultural use.

The Soil Conservation and Domestic Allotment Act of 1936 authorized payments to farmers to encourage adoption of certain soil conservation practices, including the seeding of unsuited cropland to adapted grasses. This encouragement has contributed to the speeding up of the stabilization of hazardous land. It has also stimulated the use of grass to effect a more secure and efficient farm economy and to the recognition of grass as a crop of primary importance in the new agriculture.

## Grass in Today's Agriculture

Grasses and legumes have established their place among the Nation's major crops (table 1), thanks to farmers' and ranchers' profitable experience in growing improved varieties developed and made available to meet local needs by State experiment stations, SCS and other agricultural research and action agencies, and by commercial seed growers.

Today, after a quarter century of conservation farming and ranching, the results of grassland husbandry are reflected in the economy of individual operators and that of many communities and some entire regions.

Grasses and legumes have largely taken the place of cotton in many parts of the Southeast. Beef and dairy herds thrive on improved pastures that have supplanted cotton and corn in parts of the old South. In the Southwest and Great Plains, native grasses are protecting millions of acres of soil that once blew in duststorms and are bringing increased livestock returns to farmers and ranchers. Across the West and back through the Midwest and Northeast, expanded planting and profitable management of native and improved grasses and legumes follow the national pattern of higher hay yields and increased carrying capacities on pastures.

Most grassland farmers started by using grasses and legumes for erosion control. Then they found that these sod crops were not only soil savers but were also soil improvers and moneymakers as well. Ranchers who realized that grass was the base of their livestock production learned to know their plants and to care for them with the same attention they gave their animals. The new generation of conservation farmers and ranchers has come to manage grasses and legumes as primary crops on a par with the conventional row crops and small grains of yesterday.

The stature of grass husbandry in American agriculture today is reflected in the grass conservation practices being used throughout the country by cooperators in soil conservation districts (table 2).

**Table 1.--Grassland in the United States, 1929 and 1959**

(U. S. Census of Agriculture)

| Region | Cropland used for pasture | | Woodland pasture | | Grassland pasture[2] | | Improved pasture[3] | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | 1929[1] | 1959 | 1929 | 1959 | 1929 | 1959 | 1959 | 1929 | 1959 |
| | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres | 1,000 acres |
| Northeast.... | 10,582 | 4,740 | 9,352 | 5,055 | 9,734 | 9,630 | 1,626 | 29,668 | 21,259 |
| Southeast.... | 10,056 | 14,143 | 15,857 | 24,138 | 5,344 | 17,169 | 5,181 | 31,251 | 60,628 |
| Corn Belt.... | 34,272 | 22,219 | 24,837 | 18,936 | 17,379 | 20,598 | 2,300 | 76,488 | 64,053 |
| Great Plains. | 48,900 | 18,774 | 25,543 | 24,044 | 193,435 | 324,366 | 11,555 | 267,878 | 378,739 |
| West......... | 5,257 | 6,778 | 9,620 | 15,449 | 33,779 | 92,770 | 2,926 | 48,656 | 117,923 |
| | 109,067 | 66,654 | 85,209 | 87,622 | 259,671 | 464,533 | 22,588 | 453,941 | 642,602 |

[1] Includes plowable pasture not cropland.
[2] Includes rangeland.
[3] No available information for 1929.

## Table 2.--Grassland Conservation Practices Applied With Soil Conservation Service Assistance, Fiscal Year 1962 and on the Land June 30, 1962

On farmland

| State and region | Conservation cropping systems | | Cover cropping | | Planting pasture | | Proper use of pasture | | Grassed waterways | |
|---|---|---|---|---|---|---|---|---|---|---|
| | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 |
| Connecticut | 49,202 | 6,541 | 41,342 | 4,597 | 29,345 | 161 | 25,542 | 584 | 171 | 11 |
| Delaware | 290,980 | 198,754 | 223,084 | 104,366 | 10,207 | 643 | 19,463 | 22,203 | 16 | 2 |
| Maine | 46,610 | 1,218 | 4,411 | 2,947 | 19,978 | 440 | 8,404 | 2,039 | 49,537 | -- |
| Maryland | 895,938 | 447,546 | 406,865 | 231,381 | 106,466 | 2,638 | 210,392 | 173,899 | 6,923 | 1,425 |
| Massachusetts | 44,468 | 3,675 | 37,656 | 4,833 | 22,899 | 925 | 22,610 | 695 | 29,889 | 10 |
| New Hampshire | 38,488 | 7,061 | 11,277 | 3,189 | 4,032 | 633 | 29,518 | 17,302 | 223 | 1,165 |
| New Jersey | 155,462 | 6,004 | 264,374 | 10,001 | 35,991 | 707 | 20,081 | 400 | 1,096 | 23 |
| New York | 979,904 | 19,067 | 179,097 | 9,672 | 151,946 | 1,930 | 182,598 | 6,698 | 5,005 | 3,612 |
| Pennsylvania | 798,848 | 35,908 | 92,377 | 12,882 | 124,039 | 5,316 | 20,568 | 2,175 | 14,469 | 203 |
| Rhode Island | 6,250 | 435 | 6,359 | 642 | 6,186 | 235 | 1,679 | 79 | 97 | -- |
| Vermont | 223,963 | 83,296 | 7,755 | 1,346 | 3,778 | 569 | -- | -- | 470 | 18 |
| Virginia | 1,533,379 | 42,543 | 688,657 | 33,240 | 616,800 | 23,038 | 238,482 | 3,415 | 22,282 | 691 |
| West Virginia | 212,469 | 23,972 | 12,048 | 3,949 | 75,881 | 3,663 | 851,048 | 71,617 | 3,770 | 168 |
| Northeast total | 5,275,961 | 876,020 | 1,975,302 | 423,045 | 1,207,548 | 40,898 | 1,630,385 | 301,106 | 133,948 | 7,323 |
| Alabama | 1,135,866 | 88,860 | 487,081 | 39,850 | 2,572,809 | 100,629 | 213,395 | 310 | 48,150 | 1,738 |
| Arkansas | 4,864,340 | 2,416,889 | 2,175,745 | 1,296,875 | 2,406,451 | 203,490 | 1,958,020 | 673,619 | 2,657 | 179 |
| Florida | 751,862 | 110,911 | 1,028,474 | 163,776 | 2,078,777 | 86,085 | 1,032,459 | 258,509 | 4,565 | 156 |
| Georgia | 2,893,602 | 310,381 | 1,424,662 | 237,986 | 2,380,788 | 130,250 | 361,004 | 11,274 | 78,141 | 1,004 |
| Louisiana | 1,529,238 | 277,196 | 694,832 | 114,778 | 1,170,992 | 39,631 | 1,108,324 | 197,352 | 1,791 | 2 |
| Mississippi | 3,088,279 | 267,740 | 650,708 | 238,833 | 1,948,039 | 354,528 | 1,504,387 | 489,665 | 67,115 | 260 |
| North Carolina | 2,115,701 | 72,239 | 991,312 | 76,462 | 829,400 | 37,834 | 117,480 | 2,827 | 33,106 | 5,425 |
| South Carolina | 1,892,604 | 66,366 | 654,775 | 42,370 | 802,330 | 43,918 | 368,570 | 30,238 | 26,824 | 674 |
| Tennessee | 1,244,245 | 100,381 | 624,354 | 108,659 | 2,141,454 | 130,641 | 697,424 | 167,933 | 36,700 | 3,233 |
| Caribbean | 32,772 | 2,188 | 5,121 | 260 | 243,051 | 24,514 | 347,910 | 26,427 | 21,724 | 324 |
| Southeast total | 19,548,539 | 3,713,151 | 8,737,064 | 2,319,849 | 16,574,091 | 1,151,520 | 7,708,973 | 1,858,154 | 320,773 | [illegible] |
| Illinois | 4,013,847 | 216,608 | 872,099 | 76,815 | 428,755 | 40,289 | 203,877 | 27,759 | 62,835 | 4,282 |
| Indiana | 2,069,056 | 178,211 | 487,087 | 53,548 | 307,861 | 19,102 | 43,282 | 7,475 | 163,371 | 1,571 |
| Iowa | 7,049,405 | 349,367 | 488,294 | 92,817 | 230,851 | 16,070 | 205,997 | 11,582 | 133,246 | 12,659 |
| Kentucky | 1,528,892 | 69,365 | 639,305 | 94,772 | 2,430,258 | 155,926 | 780,202 | 38,870 | 86,692 | 5,462 |
| Michigan | 1,348,140 | 211,522 | 393,496 | 150,695 | 186,072 | 10,416 | 11,033 | 260 | 6,214 | 641 |
| Minnesota | 3,864,803 | 226,293 | 752,860 | 185,293 | 158,082 | 6,158 | 124,362 | 5,231 | 19,784 | 4,864 |
| Missouri | 1,376,447 | 103,847 | 542,508 | 48,914 | 437,218 | 21,792 | -- | -- | 26,566 | 900 |
| Ohio | 4,030,310 | 238,672 | 408,866 | 59,305 | 253,829 | 7,407 | 33,061 | 4,720 | 17,132 | 460 |
| Wisconsin | 2,482,491 | 158,458 | 42,270 | 6,974 | 6,414 | 697 | 7,200 | 138 | 18,246 | [illegible] |
| Corn Belt total | 27,763,391 | 1,752,343 | 4,626,785 | 769,133 | 4,439,340 | 297,857 | 1,409,014 | 96,035 | 534,086 | [illegible] |
| Colorado | 2,935,033 | 275,909 | 85,299 | 3,138 | 601,842 | 20,725 | 184,733 | 39,777 | 4,873 | 339 |
| Kansas | 12,095,998 | 408,595 | 350,953 | 6,497 | 607,795 | 33,481 | 389,368 | 30,859 | 191,207 | 13,468 |
| Montana | 3,902,366 | 215,749 | 6,549 | 711 | 1,003,685 | 45,675 | 665,887 | 96,757 | 8,904 | 428 |
| Nebraska | 7,118,334 | 476,101 | 272,135 | 13,607 | 654,637 | 30,638 | [illegible] | 53,596 | 131,513 | 4,784 |
| New Mexico | 465,592 | 71,429 | 57,160 | 893 | 46,025 | 2,499 | 1,725 | 1,233 | 28,755 | -- |
| North Dakota | 12,414,963 | 1,528,387 | 495,316 | 68,609 | 622,748 | 36,827 | 870,245 | 107,029 | 9,410 | 452 |
| Oklahoma | 4,893,651 | 2,131,416 | 1,520,422 | 516,345 | 1,898,877 | 203,730 | 1,311,779 | 585,815 | 53,222 | 4,482 |
| South Dakota | 5,466,901 | 366,195 | 535,371 | 33,559 | 706,440 | 42,272 | 834,154 | 41,832 | 33,791 | 1,865 |
| Texas | 8,132,450 | 2,924,059 | 3,055,092 | 1,066,952 | 2,975,764 | 354,654 | 3,144,923 | [illegible] | 128,698 | 11,925 |
| Wyoming | 774,606 | 57,896 | 70,730 | 1,365 | 160,878 | 5,725 | 163,661 | 110,119 | 1,158 | 6 |
| Great Plains total | 58,199,894 | 8,455,736 | 6,449,027 | 1,711,676 | 9,278,691 | 776,226 | 8,047,158 | 2,184,216 | 591,531 | 37,749 |
| Alaska | 14,872 | 128 | 411 | 256 | -- | -- | 150 | 450 | 5 | -- |
| Arizona | 605,147 | 229,333 | 54,396 | 24,735 | 33,213 | 2,187 | 9,680 | 3,547 | 60 | -- |
| California | 1,964,834 | 431,672 | 707,276 | 151,529 | 308,816 | 34,108 | 770,359 | 213,932 | 10,887 | 19 |
| Hawaii | 152,355 | 16,017 | 961 | 855 | 77,226 | 4,472 | 360,610 | 182,597 | 146 | 7 |
| Idaho | 1,985,454 | 687,670 | 168,920 | 46,671 | 251,923 | 11,959 | 180,030 | 66,353 | 5,133 | 245 |
| Nevada | 166,499 | 30,835 | 3,131 | 1,431 | 25,083 | 2,036 | 43,234 | 19,932 | 21 | -- |
| Oregon | 782,424 | 137,735 | 130,948 | 43,242 | 307,828 | 18,239 | 188,308 | 43,976 | 2,868 | 2,537 |
| Utah | 716,586 | 234,071 | 11,390 | 3,639 | 331,632 | 9,780 | 83,543 | 42,675 | 469 | 24 |
| Washington | 3,482,089 | 1,159,219 | 447,628 | 103,046 | 301,358 | 20,915 | 313,244 | 48,210 | 10,021 | 1,379 |
| West total | 9,870,260 | 2,926,680 | 1,525,061 | 375,404 | 1,697,379 | 103,696 | 1,955,158 | 621,672 | [illegible] | [illegible] |
| U.S. total | 120,658,015 | 17,723,930 | 23,313,239 | 5,599,107 | 33,196,749 | 2,350,197 | 20,750,688 | 5,061,183 | 1,609,948 | [illegible] |

Table 2.--Grassland Conservation Practices Applied With Soil Conservation Service Assistance, Fiscal Year 1962 and on the Land June 30, 1962 (Continued)

On rangeland

| State and region | Range seeding (549+550) | | Proper range use (528) | | Deferred grazing (352) | | Rotation and deferred grazing (556) | | Brush control (314) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 | On the land | New in 1962 |
| Connecticut | | | | | | | | -- | 2,115 | 3 |
| Delaware | | | | | | | | -- | 3,000 | 7 |
| Maine | | | | | | | | 18 | 8,951 | 933 |
| Maryland | | | | | | | | 20 | 46,345 | 76 |
| Massachusetts | | | 39 | 53 | 5,270 | 708 | 6,860 | 2,938 | 21,529 | 29 |
| New Hampshire | | | | | | | | 1,182 | 3,608 | 31 |
| New Jersey | | | | | 246 | 55 | 1,806 | 293 | 660 | 2 |
| New York | | | | | 30 | 38 | 530 | 48 | 69,209 | 1,951 |
| Pennsylvania | | | | | | 77 | 1,490 | 1,258 | 38,463 | 343 |
| Rhode Island | | | | | | | 13 | 13 | -- | -- |
| Vermont | | | | | | | | -- | 230 | -- |
| Virginia | | | 1,500 | | 800 | | 2,500 | 44 | 28,338 | -- |
| West Virginia | | | | | 25 | | 1,053 | -- | -- | 508 |
| Northeast total | | | 1,539 | 53 | 6,371 | 878 | 14,252 | 5,814 | 222,448 | 3,883 |
| Alabama | -- | -- | 5,400 | 329 | 1,000 | -- | 5,500 | 20 | 184,040 | 591 |
| Arkansas | 13,494 | 604 | 641,200 | 226,736 | 331,805 | 301,618 | -- | 2,990 | 1,357,837 | 612,587 |
| Florida | 10 | 5 | 699,761 | 158,714 | 251,433 | 53,862 | 163,150 | 49,392 | 98,016 | 7,491 |
| Georgia | -- | -- | 1,500 | -- | 8,300 | -- | 12,161 | 241 | 46,129 | 123 |
| Louisiana | -- | -- | 124,700 | 36,358 | 63,860 | 32,463 | 64,298 | 29,620 | 66,454 | 640 |
| Mississippi | -- | -- | 94,689 | 4,506 | 15,457 | 2,862 | 35,608 | 13,224 | 295,796 | 6,389 |
| North Carolina | -- | -- | -- | -- | 725 | 16 | -- | -- | 13,576 | 43 |
| South Carolina | -- | -- | 25,710 | 1,357 | 3,300 | -- | -- | 992 | 70,965 | 10 |
| Tennessee | -- | -- | -- | -- | -- | -- | -- | 67 | -- | -- |
| Caribbean | 1,000 | 676 | 3,296 | 1,415 | 1,310 | 24 | 20,879 | 18,250 | 199,442 | 23,693 |
| Southeast total | 14,504 | 1,285 | 1,596,256 | 429,415 | 677,190 | 390,845 | 301,596 | 114,796 | 2,332,255 | 651,567 |
| Illinois | | | -- | -- | | -- | -- | -- | 95,865 | 1,166 |
| Indiana | | | -- | 6 | | -- | 655 | 974 | 67,442 | 4,047 |
| Iowa | | | -- | 103 | 300 | 496 | -- | 507 | 248,893 | 5,837 |
| Kentucky | | | 960 | 25 | | 23 | -- | 496 | 43,652 | 855 |
| Michigan | | | -- | 21 | | -- | -- | -- | 1 | -- |
| Minnesota | | | -- | -- | | -- | 5,360 | 7,705 | 8,879 | 93 |
| Missouri | | | -- | -- | | -- | -- | -- | 88,022 | 10,505 |
| Ohio | | | -- | 5 | | -- | -- | -- | 11,237 | 103 |
| Wisconsin | | | -- | -- | | -- | -- | -- | -- | -- |
| Corn Belt total | | | 960 | 160 | 300 | 519 | 6,015 | 9,682 | 563,991 | 22,606 |
| Colorado | 793,560 | 21,501 | 12,628,893 | 1,806,067 | 836,209 | 106,463 | 733,474 | 28,060 | 402,210 | 46,118 |
| Kansas | 1,519,887 | 29,106 | 9,375,672 | 591,675 | 1,731,750 | 165,619 | 127,301 | 868 | 784,377 | 81,407 |
| Montana | 219,160 | 14,094 | 15,758,431 | 3,203,411 | 4,077,835 | 952,312 | 623,096 | 193,542 | 621,746 | 14,272 |
| Nebraska | 583,681 | 42,008 | 9,983,154 | 2,611,902 | 3,628,097 | 737,804 | 319,049 | 2,442 | 155,224 | 23,972 |
| New Mexico | 586,328 | 15,697 | 20,629,219 | 2,931,804 | 4,191,252 | 555,508 | 430,824 | 52,670 | 623,819 | 51,170 |
| North Dakota | 63,165 | 4,781 | 5,047,841 | 829,302 | 694,435 | 112,346 | 371,526 | 36,373 | 435,188 | -- |
| Oklahoma | 1,904,729 | 72,449 | 7,323,330 | 4,648,989 | 1,407,126 | 756,916 | 128,887 | 79,822 | 920,191 | 191,052 |
| South Dakota | 182,361 | 9,177 | 9,507,209 | 2,071,894 | 2,382,435 | 333,856 | 676,195 | 82,906 | 401,146 | 459 |
| Texas | 2,726,150 | 256,746 | 37,180,798 | 23,852,232 | 15,130,144 | 7,988,964 | 6,833 | 3,946 | 13,322,852 | 1,618,036 |
| Wyoming | 66,352 | 1,543 | 8,674,140 | 3,978,847 | 3,941,659 | 1,344,000 | 689,621 | 29,780 | 231,792 | 10,332 |
| Great Plains total | 8,645,373 | 467,102 | 136,108,687 | 46,526,123 | 38,020,942 | 13,053,788 | 4,106,806 | 510,409 | 17,898,545 | 2,036,818 |
| Alaska | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arizona | 16,934 | 2,148 | 2,894,730 | 2,173,206 | 1,834,945 | 1,005,061 | 723,953 | 489,060 | 593,310 | 24,336 |
| California | 292,381 | 22,493 | 3,319,183 | 601,478 | 478,288 | 71,563 | 452,498 | 157,144 | 187,597 | 9,792 |
| Hawaii | -- | -- | -- | -- | 41,120 | 41,107 | 76,192 | 4,192 | 47,163 | 4,980 |
| Idaho | 476,223 | 25,160 | 1,613,021 | 473,296 | 502,047 | 171,952 | 475,023 | 116,202 | 434,438 | 23,109 |
| Nevada | 455,240 | 8,330 | 3,583,744 | 160,194 | 821,404 | 21,003 | 1,014,689 | 7,949 | 401,415 | 20,016 |
| Oregon | 152,045 | 9,234 | 1,668,596 | 538,464 | 548,560 | 144,789 | 606,568 | 207,684 | 174,138 | 16,995 |
| Utah | 327,751 | 10,860 | 3,534,170 | 1,488,970 | 221,373 | 129,993 | 331,059 | 202,849 | 326,037 | 20,341 |
| Washington | 68,020 | 2,568 | 3,160,304 | 839,738 | 1,298,156 | 370,391 | 1,353,014 | 397,405 | 850,507 | 5,282 |
| West total | 1,788,594 | 80,793 | 19,773,748 | 6,275,346 | 5,745,893 | 1,955,859 | 5,032,996 | 1,582,485 | 3,014,605 | 124,851 |
| U.S. Total | 10,448,471 | 549,180 | 157,481,190 | 53,231,097 | 44,450,696 | 15,401,889 | 9,461,665 | 2,223,186 | 24,031,844 | 2,839,725 |

Pasture and range planting reported by SCS as the assisting technical agency amounted to 43,645,000 acres successfully established and "on the land" as of June 30, 1962. About 2,350,000 acres of pasture and 549,000 acres of range, were seeded in fiscal year 1962 alone.

Proper use had been established on 20,751,000 acres of pasture and 157,481,000 acres of range, including 5,061,000 acres on pasture and 53,231,000 acres on range newly established in 1962. Deferred grazing was in effect on 44,451,000 acres of range, including 15,402,000 established in 1962, and brush control had been established on 24,032,000 acres, including 2,840,000 acres in 1962.

Several other conservation practices make liberal use of grasses and legumes. Conservation cropping systems include grasses and legumes in accordance with the land capability. Such systems have been established on 120,658,000 acres of cropland, including 17,724,000 acres established in 1962. Cover cropping, likewise, includes generous proportions of legumes and increasing amounts of grasses. Cover crops were used on 23,313,000 acres in 1962, including 5,599,000 newly established that year.

Grass also figures importantly in water conservation and management structures on farms, ranches, and watersheds. Among the major uses is in grassed waterways for carrying runoff water safely from cultivated fields and floodwater-retention structures. There were 1,610,000 acres of such waterways on the land as of June 30, 1962; 97,000 acres had been established during the preceding year. This figure does not include millions of square yards of sod established to protect dam faces, spillways, and other earthen structures to impound and control water.

In making these improvements, operators of range land and pasture land receive technical and cost-sharing assistance from USDA, and the aid and encouragement of their local soil conservation districts and cooperating organizations.

Impressive as it is, however, this quarter century of progress in grassland agriculture is only a beginning. The Nation's potential of grass production has scarcely been tapped, and the grassland conservation job is barely a fourth done.

## The Job Ahead

The National Inventory of Soil and Water Conservation Needs, conducted by USDA and cooperating agencies from 1957 to 1960, showed that 73 percent of the non-Federal pasture and range of the United States still needs conservation treatment and improvement (USDA 1962a).

Of the 485 million acres classified as pasture and range in the inventory (which excluded all Federal land), plus a net increase of 13 million acres expected by 1975, a total of 365 million acres was found to need conservation treatment. More than 280 million acres of this land is in the 17 Western States. These figures do not include the several million acres of forest and woodland that are used for grazing and may need grass conservation measures as part of a multiple-use program.

More than 72 million acres of the non-Federal pasture and range needs seeding to establish new grass stands. This includes about 45 million acres of present cropland, woodland, and other land expected to be converted to grassland by 1975, and 27 million acres of present grassland so badly depleted that it needs reseeding. Of the total acreage needing revegetation, more than 30 million acres should be planted to tame pasture.

Offsetting the 45 million acres coming into pasture and range, the inventory indicated that about 32 million acres would be converted from grassland to other uses: 20 million acres to cropland, 6 million to forest and woodland, and 6 million to other uses and out of agriculture. In the exchange, pasture and range will gain a net of about 13 million acres, making an estimated total of 498 million acres by 1975.

Most of the land coming into pasture and range from other uses is either eroded, wet, steep, sandy, infertile, saline, alkaline, or arid. Special treatment and management will be required to seed this land and maintain adequate cover after it is established. Revegetation and successful management will require extraordinary skill in selection of species to be planted, in seedbed preparation, and in grazing supervision.

In the Great Plains and West, greater use needs to be made of locally adapted strains of native grasses. In the humid tame pasture area, a wide variety of locally adapted strains, some of them suited to varying degrees of wetness, aridity, and fertility, are still needed.

Cost-return information will be needed to help determine which soils and plants will respond adequately to justify the cost of soil amendments and fertilizer. Careful selection must be made of plants that produce profitable forage without fertilizer.

In addition to the land needing seeding, 108 million acres or about a fifth of the non-Federal range included in the Conservation Needs Inventory, needs improvement of cover by measures short of complete reestablishment. It can be assumed that a similar proportion of the other grazing land in the United States needs similar treatment.

Further gains in forage production can be obtained from the control of unwanted brush and trees on an estimated 240 million acres of range. This includes 57 million acres of invading plants on grassland range and pasture included in the Conservation Needs Inventory; the remainder on Federal range or land classified as woodland in the inventory. Forage yields on such land can be doubled or trebled and water-conservation values improved by brush-control programs that provide adequate followup and grazing management.

The foregoing figures and examples give only a partial indication of the vital role of grass in soil and water conservation and its growing importance in the economy of American agriculture. A still greater challenge lies ahead of us. Now that a workable body of principles and techniques in grassland management have been developed, the pressing need is to extend them as we refine them for more efficient use and conservation of America's soil and water resources.

The following chapters by SCS technologists who have had an active part in the grass revolution record some of the details of that fascinating story and focus on some of the problems in their special phases of grass husbandry in soil and water conservation.

# GRASS IN CONSERVATION FARMING

By B. D. Blakely, Head Agronomist, Soil Conservation Service

When the national soil and water conservation program started in the 1930's it became apparent that there was a real need for grass on the cultivated and pasture land of the United States. Findings at the 10 soil erosion experiment stations, established in 1929, lent undeniable proof of this need. These results were soon confirmed by widespread experience of farmers themselves.

Several problems had to be solved before grass farming could move ahead. Improved kinds of grasses and legumes were needed to do the specialized jobs of protecting and improving soil, as well as producing profitable forage crops on diverse kinds of soil many of which were already badly depleted by erosion and one-crop farming. New and better planting and management techniques had to be developed by research people and conservationists working with farmers and ranchers.

Farmers had to make major adjustments in their operations if they decided to convert all or part of their land to grass. This was a new way of farming for many, requiring them to learn to grow and harvest hay and pasture crops. Often they had to acquire new machinery and provide facilities for livestock.

Among the questions facing the new grassland farmer were which grasses or legumes, or mixtures, to use; where to use them; the best methods of seedbed preparation and planting; the kind and amount of fertilizer to use; how to control weeds and pests; the procuring and adapting of the planting and harvesting machinery; and how best to utilize the forage for pasture, hay, or silage.

Several events and influences boosted the use of grasses on cropland and pastures. In 1936 the Agricultural Adjustment Administration started making payments to farmers and ranchers who planted grasses or legumes as soil-conserving or soil-building crops on cultivated land as an aid to land use adjustment. Such financial incentives for grass and legume seeding and management have continued to have a top place in the docket of permanent-type conservation practices supported in the continuing Agricultural Conservation Program.

From the beginning of its existence as the Soil Erosion Service in 1933, the Soil Conservation Service (SCS) collaborated with the agricultural colleges, experiment stations, and extension services on methods of establishing and managing grasses for hay and pasture. Recommendations were soon put into technical guides and made available to farmers and ranchers.

This cooperative process had an impact on the speed of acceptance and the extent to which the use of grass and legumes has spread. In some instances, practices recommended by the State agencies for use in one State were extended to other States as a result of field trials and encouragement by SCS. In other cases, vegetative and other practices originated with SCS and were adopted and recommended by the State agencies.

SCS land-capability summaries, research results, and farmer experiences all have clearly indicated the need for grasses on different kinds of soils to meet varying climatic conditions. This kind of information was used at the start by SCS in assisting farmers to develop conservation programs on their farms.

By 1948 enough research results were available from erosion experiment stations to enable soil and water conservation research specialists and SCS conservationists to develop a "soil loss formula" (Browning et al. 1947). By using the formula conservationists could advise farmers with greater accuracy on the kind of conservation cropping systems that were needed to protect land from erosion. The formula was first used in the Corn Belt and Northeast in 1955. This kind of information was found to be useful also in the Southeast and the eastern part of the Great Plains where water erosion is a problem. The information materially helped in emphasizing the value of grasses in reducing soil and water losses on cropland.

The last agricultural census showed 66 million acres of cropland used for pasture only and another 33 million acres in soil-improving crops, mainly grasses and legumes, or idle (Wooten et al. 1962). Pasture and range planting by soil conservation district cooperators, who operate about half the Nation's farmland, totaled 43.6 million acres by June 30, 1962 (table 2). District cooperators established about 2.9 million acres of new pasture and range in fiscal year 1962.

## Grass for Soil Protection

Grass proved to be of primary importance in the protection of conservation structures on farms, ranches, and watersheds. Special sods and turfs play a key role in carrying excess water safely from terraced fields and in protecting floodwater-retention structures.

Farm ponds and stock-water developments commonly include earthfill dams and supplemental spillways that are protected from erosion by grasses that form a dense cover. Several thousand dams built in flood prevention and small watershed protection projects have been planted to grass to protect the fills and spillways from erosion. Also, grass has been planted on some 170,000 acres to stabilize critical erosion areas and roadbanks in these watershed projects.

## Grass in the Southeast

Perhaps no other region in the United States had a larger area of severely eroded land at the outset of the national soil and water conservation program than the Southeast. This was caused primarily by generations of single-crop farming, principally cotton.

For many years in the early 1900's, agricultural colleges and other farm leadership urged farmers to change to livestock and crops other than cotton. The continuing demands for cotton, however, with the abundance of labor, absence of markets for livestock or dairy products and, importantly, the lack of grasses and legumes adapted to hot summers, all worked against a change.

Even in the mid-1930's Southeastern farmers were reluctant to shift to grass. Although soil conservationists had learned the advantages of bermudagrass for use in waterways, many farmers considered it a pest that had to be fought and destroyed in the clean-tilled fields. Improved pastures were mostly carpetgrass, common lespedeza, common bermudagrass, dallisgrass, and johnsongrass in areas where they grew naturally.

Cover crops were more important in the southern cropping system of the 1930's than today. Considerable acreages of small grain, vetch, Austrian peas, and other winter legumes were grown, as were cowpeas, velvetbeans, lespedezas, and other summer-growing legumes. Some of these still are grown, but today's emphasis is on sod-based rotations and fertilizer rather than on cover crops.

Conservation farmers throughout the Southeast are now growing their cultivated crop following 2 or more years of perennial grass sod. These grass-based cropping systems, pioneered by SCS agronomists, were not possible in most areas 25 years ago because reliable adapted perennial grasses were unavailable.

Cropping systems including perennial grasses are not yet used extensively but there is a steady increase in the acreages planted each year. Some examples are tomatoes following pangolagrass in Florida; watermelons and flue-cured tobacco following bahiagrass in Florida; tomatoes following bahiagrass in the Charleston, S.C., area; flue-cured tobacco following fescue in North Carolina; corn, tobacco, and other crops following Coastal bermudagrass in South Carolina and Georgia; and cotton following fescue in the Mississippi Delta.

In the Carolinas, Georgia, Alabama, Mississippi, and Florida, farmers are using Coastal bermudagrass, Kentucky 31 tall fescue, or Pensacola bahiagrass in their grass programs. Many use all three. Following are estimated acreages of improved grasses and legumes in nine Southeastern States (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee) in 1960:

| | Acres |
|---|---:|
| bahiagrass, Argentine | 147,915 |
| bahiagrass, Paraguay 22 | 3,721 |
| bahiagrass, Pensacola | 2,469,109 |
| ball clover | 24,582 |
| Coastal bermudagrass | 905,606 |
| hairy indigo | 206,616 |
| Kentucky 31 tall fescue | 2,840,531 |
| kudzu | 196,322 |
| lespedeza bicolor | 40,013 |
| lespedeza japonica | 4,262 |
| Mike clover | 5,337 |
| pangolagrass | 500,359 |
| sericea lespedeza | 1,202,931 |

One of the major contributions of SCS in expanding the use of grasses on the croplands of the Southeast has been through leadership in determining the amount of crop residue that perennial grasses return to the soil and their benefits to the succeeding row crop.

In 1954, SCS agronomists in the Southeast started weighing samples of grass roots and tops. In addition they obtained information from farmers on row crop yields following a sod against those where grasses were not used. These findings proved the importance of grass in the cropping systems of the South.

Agronomists found that perennial grasses produced 4 to 8 tons of material as compared to 1 to 2 tons from cereal grains. Furthermore, perennial grass residues do not decay as rapidly as those of annuals. Thus their benefits last more than one crop season and they have a more lasting effect on reducing soil and water losses.

Technical and economic factors are responsible for the rapid expansion in the use of grasses and legumes during the 1940's and 1950's. SCS plant-materials centers contributed by developing, testing, and releasing adapted species and varieties. Southern experiment stations emphasized and speeded up their testing of better forage plants. Conservationists then were able to promote the use of these newly developed forage plants. Most of the conservation farm plans that SCS technicians helped landowners develop included the use of grasses and legumes in

the cropping systems and improved pastures. Farmers were encouraged to put their steeper cultivated lands into grass with lime and fertilizer.

Meanwhile, significant economic trends were having their impact on the growing of cotton. The boll weevil helped many growers decide to quit raising cotton, some as early as the 1920's. So did the expense of keeping johnsongrass out of cotton fields. As a result of these factors and the widespread use of tractors and other modern machinery, labor began to migrate out of the Cotton Belt.

Southeastern cotton growers had to meet increasing competition from high-yielding irrigated cotton coming into its own in the West. These developments, plus increased market outlets for dairy products and meat as the South's industrial economy expanded and nonfarm consumer populations increased, opened the way for diversified farming, including grass-livestock operations.

In 1925, the Southeast had 36,727,080 acres in cotton and corn. Twenty-five years later this had dropped by about a fourth, to 27,779,902 acres. During the same period, acreage in pasture and hay in the same States increased from 31,381,885 to 64,890,247.

The 34-million-acre increase in grass against a 9-million-acre decrease in row crops shows that a great deal of grass had been planted on land that was not in cotton and corn in 1925.

But the change from cotton to cattle actually was the result of the desire of farmers and the agricultural specialists with whom they were closely associated to work out efficient and more profitable systems of land use. Many farmers were no longer interested in growing clean-tilled row crops continuously or using unimproved, low-producing pastures and haylands. They realized a need for practical technical information as well as the need for new plants.

More than a million acres was planted to pasture in the Southeast each year in 1960, 1961, and 1962, a large part of it cropland. Twenty-five years ago, only a few thousand acres of such pasture was planted annually and that was not adequately fertilized and limed.

SCS records show that by 1962 a total of about 16.5 million acres had been planted to pasture in the Southeast and nearly 7.7 million additional acres of pasture were considered to be properly used. The early pastures consisted of orchardgrass, redtop, dallisgrass, white clover, and annual lespedeza, some of which were not suited to all soils. Today, Kentucky 31 tall fescue, Coastal bermudagrass, sericea lespedeza, pangolagrass and bahiagrass are among those that lead the list of well-adapted plants for pasture and hay in this region.

How to conserve and improve soils growing flue-cured tobacco was an early problem. It was not until 1952 that a few farmers were persuaded by soil conservationists to try tall fescue (Kentucky 31) in their tobacco rotations. The trials were so successful that within a decade the use of this grass, both in tobacco rotations and other cropping systems, had become widespread.

From about 17,000 acres in 1956 the acreage of tall fescue had increased to nearly 140,000 by 1960, about 75 percent of it in tobacco growing.

Experiments for nematode control at the North Carolina Research Station showed that first-year tobacco after 2 years of fescue in a 4-year rotation brought about $200 an acre more than that grown as continuous tobacco.

It is not uncommon for farmers to produce more than a ton of tobacco on land that has been in perennial grass as compared to a half or three-quarters of a ton where no grass was used in the rotation. Furthermore, the product usually brings a higher price.

Conservation farmers in the Coastal Plain area of the South have greatly increased their use of grass-based cropping systems. They are successfully growing tobacco, corn, and other row crops in Coastal bermudagrass and bahiagrass sods, letting the grass re-establish itself after the last cultivation, and thereafter grow a row crop every second, third, or fourth year.

In the early 1950's, SCS encouraged the use of clover and Coastal bermudagrass in the cotton-growing coastal plains of Louisiana. Both proved well-adapted high forage producers, as did Pensacola bahiagrass introduced in the middle 1950's. During the next 7 years, soil conservation district cooperators planted about 25,000 acres of Coastal bermudagrass and 18,000 acres of Pensacola bahiagrass. By 1960, more than 1½ million acres were planted to these grasses.

Smith County, Tenn., is an example of what grass can do. The county's soil had been under the plow since Tillman Dixon made the first settlement in 1787 and is typical of many areas in the South. By 1945, corn yields had declined to 8 to 30 bushels an acre on most of the land. Now corn is being grown on the more nearly level land in conservation cropping systems that include grass and adequate fertilizers and yields of 50 to 100 bushels an acre are common.

Today the sloping lands of Smith County are exclusively in grass. Kentucky 31 tall fescue and Ladino clover are widely used, supplemented by such conservation measures as diversion ditches to keep bottom lands from flooding. This has resulted in increased income and better living for both the farmer and businessman in town.

Grass-based rotations are helping keep Florida in winter vegetable production. Before adapted grasses became available, landowners had to let their land lie idle after one or two vegetable or flower crops to allow native vegetation to grow and reduce soil-borne diseases and insects. Now, farmers establish

pastures of bahiagrass or pangolagrass and clover that will carry up to two cows with calves an acre. After 3 to 5 years of profitable pasture, the land is again used for vegetables.

## Grass in the Northeast

The 13 States from Virginia and West Virginia north (here called the Northeast) have a total land area of nearly 153.2 million acres, much of it rough and rolling. Timber and grass cover have always predominated, the latter including much unproductive vegetation on fields from abandoned cultivation. According to the U.S. census there were about 30.5 million acres of cropland and 29.7 million acres of pasture in 1930. By 1960 these acreages had declined to 26.2 million acres of cropland and 16.5 million acres of pasture. Much of the pasture acreage of 1930 is now in trees. Some has been converted to urban or industrial uses.

Hay and pasture have always been important in the agriculture of the region. It was only natural that improved grassland agriculture should be a primary conservation objective. There was a need for improved varieties of grasses and legumes that would give good yields of high quality forage, both in long rotations and on land used primarily for hay or pasture. In addition, applications of lime and fertilizer were needed to maintain stands and yields.

Soil conservationists started early to use the information from the erosion experiment stations to develop specifications for controlling soil losses on cropland. This led to maximum use of grass in rotations for hay and for cover and green manure crops to control soil and water losses. In addition, emphasis was given to grasses and legumes for permanent or temporary cover in the large acreages of orchards, vineyards, and vegetable crops. One method of promoting grassland agriculture was the "Green Pastures Program," sponsored by State and Federal agricultural agencies and soil conservation districts. This movement started in New Hampshire and later spread throughout the region.

Before the conservation program started, timothy, orchardgrass, and redtop were the chief grasses on cropland and bluegrass was the main pasture grass. The main legumes were alsike, white, and red clovers, and sweetclover; there was some alfalfa. Since 1930 new alfalfa varieties have been introduced as the result of the work of plant breeders, and alfalfa acreages have increased from 415,000 acres in 1930 to 2,331,000 in 1960. Tall fescue is now an important grass in the rotations and pastures of Virginia. It is also widely used in grassed waterways that are so prevalent in the Northeast. Reed canarygrass, once thought to be useful only in waterways, is gaining wider acceptance for hay and pasture, since there now is knowledge of how it can be managed.

Birdsfoot trefoil is a legume often used in the permanent pastures of New York and Pennsylvania. It is also used for hay on soils too wet for alfalfa and is replacing red clover in seeding mixtures. Except on steep land, short-type pasture grasses have given way to mixtures of alfalfa or Ladino clover, or both, with smooth brome or orchardgrass.

Field brome and ryegrass make up most of an estimated 422,000 acres of cover crops planted each year, much of which is in the cash-crop sections. Field brome, a winter annual, was first used extensively as a cover crop in the Northeast. It provides good cover from fall to spring and in addition produces large quantities of roots. SCS has helped increase the use of a new variety of this grass, Svalofs Sleipner, which is hardy enough to survive in Maine.

USDA records show that the total acreage of hay harvested in the Northeast decreased somewhat between 1933 and 1960--from 11,530,000 acres to 9,359,000 acres--but that yields per acre increased.

A quarter of a century ago Northeastern pastures of unfertilized Kentucky bluegrass, Canada bluegrass, and wild white clover provided feed only during the early part of the grazing season. At least 5 acres was needed to provide 1 animal-unit of grazing. Clover-timothy hay yields were about $1\frac{1}{2}$ tons per acre and alfalfa and timothy produced about 3 tons per acre. The new varieties of grasses and legumes now in use along with modern grassland management has made it possible to supply the year-round roughage needs of one cow from as little as 2 acres.

Grassland farming has resulted in improved economic conditions for many in the Northeast. A survey in 1960 by SCS on 20 Pennsylvania dairy farms in 10 soil conservation districts showed that the farmers had longer rotations and more acres in high-yielding grasses and legumes. They had increased their use of fertilizer and lime and established soil and moisture conservation practices. The average number of milk cows on their farms increased from 18 to 47 after land reorganization and treatment.

Gross income, based on 1959 prices, increased from an average of $7,103 before conservation farming to $11,644 after treatment, or an increase of $4,541. Higher pasture and hay production was credited with being largely responsible.

## Grass in the Midwest

The Midwest as discussed here includes the nine Lake and Corn Belt States that lie between the Great Plains on the west and Pennsylvania and West Virginia on the east.

Soon after settlers came to this section small grain production became the major agricultural enterprise. In the early 1900's these States produced

more wheat than the area now considered the Wheat Belt. Later, small grain farming gave way to diversified farming, and the livestock and corn economy began to develop.

By the 1930's the major problem in this feed and dairy region was soil erosion and depletion after longtime intensive cropping with inadequate use of lime and fertilizer. The need for grass crops and better pasture management, along with other soil and water conservation measures, was apparent to soil conservationists when the national soil conservation program started in 1935.

Most of the crops grown in the Corn Belt and Lake States are used to feed livestock. Forage crops for hay, pasture, and grass silage are essential in Midwest farming. Considerable knowledge about forage crop production, management, and utilization had been accumulated as a result of cooperative research by Federal and State agencies and years of on-the-farm experience.

Before 1930, State experiment stations and the extension services had strongly recommended the use of legumes such as alfalfa and red clover to supplement timothy for hay. This helped the Corn Belt to become one of the leading alfalfa regions of the country before the 1940's and to spread alfalfa to 12.2 million acres in these nine States by 1960 (U.S. census). State and Federal experiment stations working together also developed winter hardy and disease resistant varieties that are productive and long-lived when properly managed.

The development and spread of conservation grass crops in soil conservation districts, with the help of SCS, has been a major contribution to overall agricultural advancement in the Midwest during the last 25 to 30 years. The acreage of both tame hay and pasture is greater than corn and small grains in Indiana, Michigan, Missouri, Ohio, and Wisconsin. In Illinois, Iowa, and Minnesota the acreages are about the same.

Results at soil-erosion experiment stations contributed to the development and use of grasses in conservation farming. SCS plant-materials centers, in cooperation with agricultural experiment stations, other agencies, and soil conservation districts, tested and evaluated many grasses and legumes for erosion control and land use improvement purposes.

This work led to the discovery of a number of plants with superior qualities that are now in common use throughout the Corn Belt. Southern-type bromes, for example, have generally replaced the northern-type smooth brome since 1940 in general use in the Midwest as a companion crop with alfalfa in meadows, pastures, or ground covers. Ladino white clover became an important legume in hay and pasture seeding mixtures, especially on soils that tend to be wet.

Throughout the southern part of the Corn Belt Kentucky 31 tall fescue was found to be valuable for pasture on soils that tend to be too wet for brome. It is also used for waterways, fills, cuts, and similar areas where serious erosion may occur.

Until the spread of Kentucky 31 tall fescue in the 1940's, a green field seldom was seen in the winter in western Kentucky. By 1960, a winter traveler on Kentucky highways was seldom out of sight of green fields. In 1940, Kentucky 31 tall fescue was limited to a total of probably not more than 100 acres on the Suiter farm in Kentucky, on the University of Kentucky farm, and on a small number of selected farms for seed production. By 1960, there was an estimated 1-3/4 million acres of Kentucky 31 tall fescue in Kentucky alone and uncalculated acreages growing elsewhere in the southern part of the Midwest.

Sericea lespedeza, a legume that played an important part in Kentucky's grassland program, was introduced to farmers about 1930 by the University of Kentucky Extension Service. SCS encouraged its use in soil conservation districts.

Empire and other adapted varieties of birdsfoot trefoil were brought into the Corn Belt in the 1940's. Iowa, Indiana, and Illinois led the way in the use of this plant to improve forage production on bluegrass pastures. In 1960 Iowa had more than 100,000 acres of trefoil. In the 21 northwestern counties of Illinois, more than 6,000 acres of trefoil were planted between 1955 and 1960. This plant used with bluegrass, brome, or other adapted grasses has extended the grazing period on pastures and doubled the production of milk or meat over what could be expected from unimproved pastures on similar soils. Research at Iowa State University showed steer gains on unimproved bluegrass pasture averaging from 70 to 130 pounds an acre; when the same kind of pasture was renovated and seeded to trefoil the average gains were from 150 to 450 pounds to the acre.

Illinois farmers' experience has been that birdsfoot trefoil fills a gap in their conservation grazing program on steeper lands because of its long life and high-feeding qualities. Yields in pounds of beef per acre from trefoil-brome pastures are comparable to those of alfalfa-brome. The area of birdsfoot trefoil continues to increase in northern Illinois, but its southern limit remains to be established.

Renovation of unproductive bluegrass pastures increases forage production and reduces soil and water losses. The method was recommended by agricultural colleges in the Corn Belt in the 1930's and demonstrated in the early soil erosion demonstration projects. It holds importance for many conservation farmers.

Soil conservation district cooperators planted 769,000 acres of cover crops in 1962, compared to 63,000 acres in 1950.

Typical of this rapid expansion in the use of cover crops is the experience of Dunklin County in the "Bootheel" of Missouri. In 1949, with the help of the Soil Conservation Service, Extension Service,

and other agricultural agencies, farmers began seeding 20 pounds of hairy vetch and 1 bushel of rye to the acre for winter cover and green manure crops on sandy soils that had a problem of wind erosion. The effectiveness of this practice in controlling soil blowing led to widespread use of windstrip farming. By 1960, of the 200,000 acres once plagued by wind erosion in the county, 143,500 acres were being stabilized annually with cover crops.

Grass cover crops were used on a limited scale in the 1930's and 1940's in Ohio's northwest counties. In 1960 farmers in five counties planted nearly 89,000 acres. Field trials started in 1955 by SCS agronomists and plant-materials specialists with tall fescue, ryegrass, and field brome were responsible for a part of the increase. The grasses provided more residues to plow under and made it possible to plow earlier in the spring. Also, when the cover crop was planted in row crops at the last cultivation, the fall growth provided a better footing for harvesting equipment.

Soon after SCS started work in 1935, it was called upon to help control moving sand dunes in Ottawa County, Mich. It found that European or American species of beachgrass could be used satisfactorily to stabilize the shifting sand, after which the affected areas could be reforested with various species of pine. This method proved to be both effective and economical.

## Grass in the Great Plains

The 10 Great Plains States, making up 37 percent of the United States mainland, bisect the country from Texas and New Mexico in the south, to North Dakota and Montana in the north.

Originally, about 65 percent of this 707-million-acre area was covered with grass. But in less than 100 years since settlers pushed into this region millions of acres of fertile grasslands went the way of the plow. Much of this occured during World War I and World War II when the demand for wheat production from the Nation's "granary" was greatest.

There were about 168 million acres of cropland in the 10 States in 1930 (U.S. census). Little thought was given to converting cropland permanently to grass before the mid-1930's. It took the severe duststorms during the drought years of that decade to awaken the people of the Plains to the fact that some of this land could not be successfully used for cultivated crops. But even in the face of these hazards the number of acres used for cropland continued to mount.

A peak in cultivated land acreage was reached about 1954, when there were 181.5 million acres. By that time, the effects of World War II and the postwar "plowup" had run their course. Since then, and especially during the late 1950's, extensive acreages of cropland and depleted rangeland have been returned to grass.

During this period cost-sharing payments for restoring land to grass were provided by the Agricultural Conservation Program, the Conservation Reserve, and the Great Plains conservation program. Cooperators in the Great Plains conservation program have planted grass on about 25 percent of their cropland. This amounted to 688,200 acres out of 2,812,720 acres of cropland under contract on June 30, 1962. By 1959, cropland in the Great Plains had decreased to 155 million acres (Wooten et al. 1962).

The first substantial acreage of cropland to be reseeded to grass was on submarginal land in the Federal Government's land-utilization program. The projects started in 1934 at a number of locations throughout the Great Plains and in intermountain areas of the West. In the beginning there was a shortage of available information, from either research or experience, on methods that could be used to establish grass on these semiarid lands. Sufficient quantities of adapted seed were not available.

The Soil Conservation Service, Agricultural Research Service, and State experiment stations joined forces to work out practicable seeding techniques and to develop seed supplies. Up to that time the grasses that had been used for seeding were smooth brome and crested wheatgrass, but they were limited to the central and northern Plains. This situation led to the collection of seed from native grasses, and to the start of work at SCS nurseries and some experiment stations on seeding methods and seed production.

As initial seed supplies became available, field-evaluation plantings were made by SCS plant-materials specialists on the projects. Later plantings were made on farms and ranches typical of locations needing grass seeding. Although sizable acreages were seeded on Federally owned land, much of the seeding on private land during the first 10 years was in the form of trials or demonstrations. About 1945 the breakthrough in availability of seed and the discovery that grasses could be established successfully with drills designed to plant in the stubble and mulch of sorghum resulted in rapid expansion of grass seeding in the Great Plains. This enabled farmers to plant grasses and legumes on their cropland in areas where it had been difficult to get stands.

The increased demand for seed encouraged many farmers to plant grasses on their cropland for the sole purpose of producing seed as an added cash crop. In Kansas, for example, 214 farmers in 1960 grew native grass seed crops on a total of 3,225 acres of irrigated and 1,835 acres of nonirrigated land. Between 4 and 5 million pounds of seed was produced under irrigation in that year. Interest in this kind of seed production has centered in the high plains of Texas around Lubbock. That area alone produced about 1 million pounds in 1959. Interest

was high also in southwestern Oklahoma, southwestern Kansas, and central Nebraska.

In eastern Kansas, Oklahoma, and Texas, the use of improved grasses in pastures and rotations has become more and more widespread. Thousands of acres are going from cropland to pasture and from brush to improved pasture. Farmers in eastern Kansas are converting brushy pastures to brome.

Today there is little cultivated cropland in eastern Oklahoma. Bermudagrass now covers these areas, thanks to improved varieties and hybrids, and to its value for hay, pasture, and erosion control. Bermudagrass has long been a favorite for grassed waterways and for bank stabilization. Commercially built root harvesters and spriggers have helped make it easy for farmers and ranchers to establish large acreages of bermudagrass for pasture and hay. During the fiscal year 1959-60, more than 144,000 acres were established in Oklahoma in this manner. Availability of grassland drills and other equipment owned by soil conservation districts and individuals have made it practicable to seed vetch, small grain, clovers, and lespedezas in bermudagrass sod, thereby lengthening the grazing season.

SCS records show the following acreages of grasses were established in Texas in fiscal year 1962; nearly 12,000 acres of waterways; 21,000 acres of hayland; and 355,000 acres of pasture. In addition, 696,300 acres of pasture and hayland were improved by reseeding. These acreages are equal in size to the total acres of cropland in Connecticut, Delaware, and Massachusetts in 1958.

Development and use of adapted varieties and improved species have provided cool-season grasses for early spring grazing and warm-season varieties for summer and fall pasture. Farmers are now able to plan for a longer grazing season on their pasture, which in many cases relieves the grazing pressure on rangeland.

In Montana and Wyoming, in an area of low rainfall, successful methods of grass planting were developed by SCS agronomists and crops specialists from the State experiment stations. These men found ways to establish grasses in rows, with proper use of fertilizers and management, in an area where it had seemed impossible before. The methods were so successful that they are now in common use by farmers and ranchers in the area.

In the watershed program of SCS, grasses and legumes are being used to vegetate the areas around reservoirs that are designed to store runoff water temporarily. Since many of those areas are used for pasture, it is important that the land be planted to grasses that can survive temporary inundation.

The Soil and Water Conservation Research Division of Agricultural Research Service and the Soil Conservation Service started a cooperative project in 1958 at Chickasha, Okla., to determine the tolerance of several grasses to inundation. The studies have begun to yield information for use by SCS personnel throughout the country.

## Grass in the West

The seven States in the western part of the mainland present a vast number of different conditions in soil, climate, and elevation on dryland and irrigated land where grass and legumes are needed. In the early days of the national soil conservation program, it was necessary to develop new varieties and seek new species that would fulfill the conservation objectives on cropland, pastures, and orchards. SCS has made significant accomplishments in the last 30 years in the selection and development of plants adapted to the many conditions. Although some of the improved grass management and conservation practices were not entirely new, SCS obtained their acceptance by farmers and ranchers throughout the West.

For example, for many years irrigated pasture mixtures containing several kinds of seed were recommended. Often the growth habits of these plants were different, making it difficult to manage the stands. SCS devised simple mixtures containing only one or two grasses and a legume. These simple mixtures contributed greatly to widespread establishment of improved irrigated pastures.

Another common cause of failure of grass seedings in the West was planting seed too deep. To overcome this, SCS started trials in 1938 of different depths of seeding. The findings led to the use of depth regulators on grass drills. Today, many farmers and ranchers have drills equipped with regulators on the furrow openers and are much more successful in getting grass stands.

Landowners in the West use legumes extensively as soil conditioners on both dryland and irrigated fields. These crops help improve tilth, allowing more of the natural rainfall and irrigation water to enter the soil. Several States are using the soil-conditioning effects of grasses and legumes as the basis for determining alternative conservation cropping systems for different kinds of soil.

According to the U.S. census, there were about 1.8 million acres of irrigated pasture in the seven western States in 1940. This had increased to 7.5 million acres by 1960. Increased availability of water accounts for much of the change, but development of improved varieties and introduction of new species of grasses and legumes, plus better knowledge of how to manage the pastures, also helped the spread of irrigated pasture.

For example, the use of Goar tall fescue and Alkar tall wheatgrass made successful pastures possible on saline and alkaline soils. Twenty-five years ago very few if any of the grasses could be used on such soils.

Farmers in Washington and many other areas in the West are getting 1,100 pounds of beef per acre with good management in areas where they can get 160 days of grazing. Latar orchardgrass - Ranger alfalfa irrigated pastures under good management produce 12,000 to 15,000 pounds of milk per acre per year.

Farmers in the Gold Ridge Soil Conservation District on the coast north of San Francisco are among those who have put grass to work in many ways. They are growing winter cover crops and using sod waterways and storm drains. Where water is available, orchardists are establishing permanent irrigated cover crops. Livestock men are using perennial grasses or clovers for hay instead of oats and vetch or are changing hayland to pasture. Out of 15,000 acres of eroded hayland, 10,000 acres are already converted to perennial grasses and legumes.

These farmers have also converted several thousand acres of once severely eroded cultivated orchard and hayland in land-capability classes IV, VI, and VII to crops having year-around cover. All but 300 acres of 1,500 acres of sand dunes along the ocean near the community of Bodega Bay have been controlled by planting European beachgrass.

Cover and green manure crops have always been important in the agriculture of the West, but their use is expanding as conservation-minded farmers realize their benefits in improving soil tilth and providing cover for periods of intense rains. SCS records show that over 222,000 acres of these crops were planted in 1955, and more than 375,000 acres in 1962.

The introduction and development of Lana vetch and Blando soft chess, two annual reseeding plants, have helped materially to increase the acreage of cover crops. Both of these plants are also being planted on large acreages of eroded dry cropland and on annual spring pasture.

It is estimated that there are more than 4 million acres of wet meadow land in the mountains of 11 western States. Mismanagement of these areas for the past four decades has resulted in low yields of poor quality vegetation. One of the outstanding achievements in grassland agriculture in this section has been the improvement of these mountain meadows. By introducing more productive grasses, controlling irrigation, and using fertilizers, growers increased production from $\frac{1}{2}$ to 1 ton of hay per acre up to 3 to 5 tons.

## Grass in Hawaii

Livestock is no newcomer to Hawaii. But today the need there is for the wider establishment of the better grasses and legumes and improvement in their management to obtain more high quality forage.

SCS is encouraging the use of such improved grasses as pangolagrass and kikuyugrass for the more humid areas, guineagrass (including an improved variety known locally as green panic) for the areas having a distinct moist and dry season, and buffelgrass for the arid areas.

Until recently koa haole and kaimi clover were the only important pasture legumes. Big trefoil is being used increasingly with pangolagrass and kikuyugrass in the more humid pasture areas of the Hamakua coast and Kona.

Use of fertilizer on grasslands is a new practice in Hawaii. It makes it possible to grow legumes where they could not be grown before and increases the quality of forage produced in the humid areas. While there are many unsolved fertilizer problems on the humid tropical soils, conservation farmers are making rapid progress in fertilizing intensively managed pastures.

Rotation grazing has gained acceptance during the last 5 to 10 years, especially where other improved practices have become common.

Large areas of brushland are being bulldozed every year and seeded to improve pastures. Brush control is a continuing problem on most Hawaii pastures. Mowing, spraying, or dragging with a heavy chain to prevent the return of brush are practices being used where the operation of equipment is feasible.

## Grass in Alaska

As recently as 1948, grass was little used in Alaska's Matanuska Valley, where settlers first came to the Government's Matanuska Colony farming project in 1935. Their first concern was to clear land for growing potatoes and vegetables. Also, it seemed to be the consensus that grass would not grow in the valley.

Through efforts of the Alaska Experiment Station and SCS, working through the Alaska Soil Conservation District, it became apparent that there was a place for grasses and legumes on dairy farms. After trials with these plants on district cooperators' farms, using heavy applications of fertilizer, the trend gradually began to swing to these crops for hay, silage, and pasture. By 1960, about 75 percent of Matanuska Valley's cleared farming land, or something more than 4,000 acres, was in a perennial grass rotation.

Formerly, annual crops were used for forage. Yields averaged about $1\frac{1}{2}$ tons per acre and usually had to be used as silage because of unfavorable haying weather. By contrast, fertilized brome, the principal grass grown in the valley, produces a much higher tonnage in each of two cuttings. The first crop can be field-cured and made into good-quality hay, and the second can be put in the silo if weather conditions are not favorable for haymaking. These advantages have helped shift from annual forage crops to perennial grass. An important advantage of grass in Alaska, also, is that it eliminates the danger of erosion on

the limited and hard-to-come-by cleared land, even though stubble left from annual crops harvested did help to hold down soil erosion.

As the demand for milk increases, the feed for more cows has to be raised largely on the cleared land. Good quality, high yielding forage crops are an essential alternative to expensive, if not prohibitive, clearing of new land.

To that end, experiments are being continued in an effort to develop better strains of grasses and legumes that will enable farmers to grow needed quantities of good quality grass-legume feed.

Ranchers, realizing that grass is the base of their livestock production, have learned to know their plants and care for them with the same attention they give their animals.

# CONSERVATION OF PRIVATE RANGELAND

By B. W. ALLRED, Head Range Conservationist, Soil Conservation Service

A generation ago the United States had no well-defined philosophy concerning grass. The Nation's vast natural grazing lands had been taken for granted. They were used freely, but with little appreciation of their basic forage resources. There developed no national tradition or popular terminology dealing with the use of grass, such as existed for cattle, sheep, corn, and cereals. History and folklore developed around the plow, the forests, the rivers, pioneers, and cowboys--but not around grass.

In the national program of land settlement and development, grassland was placed in a kind of escrow pending the arrival of the breaking plow. That unsuited to the plow was regarded as wasteland.

The early cattlemen, however, did little lasting damage to native grasslands. Severe droughts and blizzards held livestock numbers in check, and ranges had occasional, though unplanned, periods of recuperation. Damage to grass came after the homesteaders fenced the better land for crops and pushed range livestock raising onto less productive areas.

Between the Civil War and 1890 western cowboys trailed their cattle east, north, and west to new ranges and to markets. Although the cowboy lived by grass, he knew only how to use it, not how to perpetuate it. Not realizing its needs, he was responsible, through his methods of handling livestock, for grassland depletion on millions of acres, particularly in arid and semiarid regions.

During World War I some 50 million acres of Europe's most productive land went out of agricultural use, and a like acreage of grazing land in the United States was broken and planted, mainly to wheat. Much of this new cropland in the Great Plains was not suited to cultivation. It now is classed as submarginal and is part of the 75 million acres indicated by the National Inventory of Soil and Water Conservation Needs as needing to be returned to permanent vegetation (USDA 1962a).

## The Need for Basic Knowledge

As the national soil conservation program got under way in the 1930's, agricultural leaders who foresaw the requirements for restoring and improving natural grasslands realized that little could be done until technicians who served landowners had sound basic knowledge about their subject which they could demonstrate and teach to grass users. Teachers of agriculture and the personnel of action agencies in government first had to learn to identify the important native and domesticated plants before they could correctly evaluate their reactions to grazing, drought, fire, wildlife, and insects. Landowners, too, had to know the different grass species and understand their ecological requirements before they could become successful practicing conservation farmers and ranchers.

The inadequacy of means of spreading grassland knowledge among landowners was partly responsible for the rangeland conditions that prevailed in the 1930's. Important facts on grazing were recorded mainly in technical language unfamiliar to most range users and agricultural workers. Most of the scientific knowledge about grass was held by specialists in government agencies and in the agricultural colleges who had little contact with the grass-using public.

The need for widespread dissemination of this information was evident. Grass conservation requires understanding of the principles of botany, ecology, and grazing management. These needed to be conveyed in common language to the segment of the public that could use them on the land.

Moreover, at that time there was no precedent for applying the principles of scientific range conservation on privately owned land. When the Soil Conservation Service (SCS) began its work on demonstration projects and in Civilian Conservation Corps areas, it necessarily recruited its range technicians from the small corps of professionals working on public land.

In their new jobs these range specialists were confronted with an entirely new relationship with range users. In administering the grazing of public land, it had been their function to issue permits to livestock owners specifying the number of animals to be grazed and the season the range was to be used. In striving for conservation of privately owned range, however, they had to leave these decisions to the stockmen themselves. Only the range owner or user could decide how many animals he would graze on his land or when and where he would graze them.

## The Rancher-Technician Team

SCS, therefore, bent its efforts to assembling, cataloging, and originating modern range-management procedures that could be understood and used by private ranch operators. The new conservation agency considered its function to be to inform, show, and help ranchers and farmers in the proper management of their grass. Its range conservationists concentrated on giving livestock growers practical

information about soil, vegetation, and watershed management, and in providing them with economic evaluations of ranges used by livestock and game animals.

SCS men encouraged and aided grassland users in planning and applying the conservation treatments that such analysis indicated were needed and feasible. From this experience it became evident that people who own and operate land will accept responsibility for its conservation if they are fully informed and are provided with the kind and amount of assistance needed to supplement their own knowledge and resources.

Soil conservation districts, which now embrace 93 percent of the Nation's farm and ranch land, provide the mechanism of making this kind of assistance available to cooperators. It took many years for SCS to assemble and train the staff to meet the demand for this kind of service. Now, however, trained range conservationists are working through soil conservation districts in all grazing regions to help land owners and operators develop their own conservation plans.

Under modern planning procedures, the knowledge and judgment of the range conservationist are transmitted to the stockman who combines the new information with his own knowledge. He then can make informed conservation decisions based on the principles of prudent land use. The operator's decisions are recorded and put in a folder with information about soil, range site, and range condition and with other guides helpful in carrying out the needed conservation treatments.

As of June 30, 1962, such conservation plans had been made on 52,359 ranches totaling 152,465,640 acres, and proper use had been established on 20,750,688 acres of pasture.

## Range Site and Range-Condition Classification

One of the major factors in the success of range conservation on private land is a system of evaluating range resources that can be applied simply and quickly in the field and that can be understood and used by the ranch operator.

Such a system of range appraisal has been developed by technicians of SCS as they have helped land owners and operators analyze grassland conditions and plan practical grazing systems. The resulting system is a classification of range site and of range condition now in widespread use in soil conservation districts.

The classification is essentially an economic and ecologic evaluation of range resources. It provides a relative index to soil productivity and shows the comparative yield of vegetation for multiple uses on various range sites in four range-condition classes. It enables the rancher or farmer to know the capability of different kinds of rangeland in his holdings in terms of the kind and quantity of forage they can be expected to produce, and to appraise their present condition in relation to the potential--or "climax"--that can be expected.

The range procedures now used by SCS were developed progressively, and many have made significant contributions to them. As early as 1935, L. A. Stoddart, an SCS range conservationist in the Northwest, used a range-condition classification as a working tool with ranchers.[1] He prepared colored maps to show where changes in grazing management were needed to improve the range. To a large extent, these boundaries followed forage use patterns.

Both Soil Conservation Service and Forest Service range specialists made range-condition evaluations and published a number of descriptions of their methods in the 1940's (Canfield 1948, Costello and Turner 1944, Dyksterhuis 1949, Ellison and Croft 1944, Ellison 1949, Humphrey 1945, 1947, and 1949, Pickford and Reid 1942, Reid and Pickford 1946, and Renner and Johnson 1942). Photographs of ranges in a variety of conditions appeared in publications and in displays in public places. These were effective in alerting the public to the opportunities for range improvement.

Although early range-condition classifications were helpful, the procedures generally fell short of the need. Methods were loosely conceived and each range specialist had his own standards of appraisal. Although "excellent" usually meant something exceptionally good, no objective standards were established for determining what was excellent. To a few specialists, excellent condition represented a bona fide vegetation climax as they understood it. To others it was some utilitarian departure from climax which they personally favored. In each locality the range specialist graded ranges into four or five condition classes in accordance with his own personal viewpoints.

Another important source of difficulty was the fact that range-condition standards were not always solidly related to a soil or group of soils capable of producing about the same kind and amount of climax vegetation. Too often the classification was applied without regard to different kinds of range throughout a geographical area.

In early attempts to associate range conditions with kinds of land, some range specialists tried to apply condition-class ratings to the "western range survey" types (Humphrey 1945). Since these types were defined entirely by the prevailing aspect of the present vegetation, such a process often led to the absurd result of grading ranges already in poor condition into four or five degrees of retrogression.

By 1943 the SCS had made sporadic progress in correlating ranges in excellent condition with kinds of land or soil potentially capable of producing particular climax plant communities. L. A. Stoddart and

[1] Grazing reconnaissance class key, by L. A. Stoddart. Mimeo. sheet 330, SCS Northwest Region, Portland, Oreg. August, 1935. Unpublished material for in-Service use.

Arthur D. Smith (1943) proposed five range-condition classes, the first being the undisturbed climax and the last having no climax plants.

Also in 1943 the loss of range specialists to the armed services forced SCS to consider a range-survey method that could be applied more quickly and simply than the western-range-survey method then in use. A range site and condition survey was started in the SCS Northern Great Plains Region and starting stocking rates were assigned to each condition class for each site. Before that time apparently no one had attempted to use condition classes as a range-inventory procedure for determining grazing capacity. The method was improved and adopted in its present form in the SCS western Gulf Region in 1946 to replace the western-range-survey method[2].

In the modern survey procedure, rangeland is defined as land on which the climax, or potential, plant community consists principally of native grasses, forbs, and shrubs that are valuable for forage and are in sufficient quantity to justify its use for grazing. It includes natural grassland, savannahs, and chaparral useful for grazing.

A range site is defined as a distinctive kind of rangeland with a certain potential for producing range plants. The range site retains its capacity to reproduce this climax plant community so long as the environment remains unchanged. The various range sites are identified by (1) differences in the kinds or proportions of plants that make up the climax plant communities or (2) differences in the total yield if the vegetation in the climax plant communities is nearly the same.

Range condition is the present state of the vegetation compared to that of the climax for a particular range site. Identifying the condition of a range provides an approximate measure of any deterioration that has taken place in the plant cover, and, thereby, provides a basis for predicting the degree of improvement possible. Four classes are used to express the degree to which the composition of the present plant community has departed from that of the climax. They are defined as follows:

| Range-condition class: | Percentage of present vegetation that is climax for the range site |
|---|---|
| Excellent....... | 76 to 100 |
| Good............ | 51 to 75 |
| Fair............. | 26 to 50 |
| Poor............ | 0 to 25 |

Range site and condition surveys are not used to determine stocking rates. Rather, starting stocking rates based on information from properly grazed range are applied to adjoining ranges with similar sites and conditions. Starting stocking rates, as well as productivity indexes, are also developed for introduced grasses, such as crested wheatgrass, that are perpetuated by cultural practices rather than through plant succession. Range condition as used here, however, does not apply to introduced grasses planted on rangeland.

## Flexible Conservation Grazing Plans

One of the features of grazing plans developed by SCS is flexibility to permit the rancher to adjust his operations to the fluctuating climatic conditions normal to most range areas.

In humid regions grass growth may vary 250 percent between wet and dry years, and in arid regions as much as 800 percent. Conservation plans developed to cushion the effects of drought have proved effective in protecting grass resources and stabilizing ranch income.

With a reserve of forage on properly grazed ranges, ranchers are better able to adjust livestock numbers without being forced to sell on a depressed market. By maintaining 20 to 30 percent of grazing animals as steers or other dry cattle that can be disposed of quickly, the drought-pressed operator can easily reduce livestock to save feed for his base herd. Developing more dependable water and providing extra hay are other conservation practices that help during dry years.

Flexible conservation grazing programs, in contrast to plans based on fixed carrying capacities as were commonly recommended by early-day range specialists, have contributed to progress in range conservation in soil conservation districts.

## Conservation Cost-Return Information

In its effort to help soil conservation district cooperators plan and apply economically sound conservation programs, SCS has developed a system for obtaining cost-return information on the different conservation treatments applicable to different land uses.

Such information on grazing land helps the rancher understand why he can make more money from proper grazing than by overusing his grass. Although beef yields may be about the same or greater from heavily used range than from that properly used, net returns from the latter are consistently greater. In general, it has been found that ranches with range sites in good condition produce about 25 percent more meat per animal-unit and per acre than those with similar sites in fair condition.

It is not the function of SCS to tell cooperators how much their operating expenses should be, but it is possible through the use of cost-return analyses to show operators where they can make economical adjustments that contribute to successful conservation plans.

[2] How to classify grasslands. SCS Region 4, Fort Worth, Tex., Range Fieldbook 111, pp. 1-10. Sept. 19, 1947. Handbook for in-Service use.

## Range Cover Evaluations

Field studies by SCS range conservationists of the soil-protective values of grass cover on ranges, pastures, meadows, and cropland helped to bring into sharp focus the role of grass in soil and water conservation.

One series of such studies in Texas and Oklahoma in 1949 and 1950 used a "mobile raindrop applicator" to subject field plots to standardized applications of artificial rainfall. Measurements of soil splash and runoff from the plots provided information on the relative effectiveness of different kinds and amounts of cover in protecting the soil from splash erosion and related influences on water intake.

The first equipment of this kind to be used on field plots was tested at the Amarillo Conservation Experiment Station in the spring of 1948. A preliminary report[3] of this work outlined the principles involved and indicated the important results to be obtained from such field tests. From this beginning, an improved model of the raindrop applicator was designed (Osborn 1953).

A field crew in 1949 made field evaluations of native range cover on 12 major sites in Texas and Oklahoma. In 1950 they made similar evaluations of common field crops and of grass cover on tame pastures, native meadows, and old fields.

These tests showed that native range cover of every type tested was sufficient on examples of every range site to prevent significant soil losses from "points of origin" under field conditions. Cultivated crops, too, were found fully effective on some plots but generally were inadequate to prevent runoff and erosion under prevailing farming practices (Osborn 1953, 1954a, 1954b).

Likewise, cover and soil conditions can be such as to prevent significant water losses from high-intensity rains on most deep soils although some shallow soils and those with restrictive layers near the surface could not absorb all the water applied under any cover conditions. All soils, however, lost large proportions of the applied water when bare or in a deteriorated condition (Osborn 1952).

The studies showed that the amount of cover on the soil surface at the time of the rain is the primary factor in preventing soil erosion by raindrop impact. But the bulk and total weight of cover and the thoroughness of its distribution over the surface also are important.

In general, the effectiveness of cover in preventing both soil and water losses is greatest on "excellent" condition range and progressively declines as the degree of current grazing use increases. On most sites, soil splash can be controlled even in the poorest range-condition class by nonuse or by grazing light enough to leave sufficient cover on the surface to intercept rainfall. When the soil surface is stabilized, conditions are favorable for improved water intake and development of the cover toward a superior and more productive range-condition class.

These and similar studies provided information that helped convince range users of the benefits of grass conservation.

[3] Ellison, W. D., 1948. Experiments in soil erosion and infiltration on range lands, in the high plains. U.S. Soil Conservation Service, Forth Worth, Tex., 22 pp. Mimeo.

## Dispelling Misunderstandings

When the national interest in grass heightened in the 1930's, dispelling erroneous notions that hindered progressive thinking about grass was one of the tasks that had to be faced.

Misunderstandings about the usefulness of many grasses came about because specialists and growers assigned "palatability ratings" to grasses based on mistaken notions of animals' grazing habits. By observing animals' feeding preferences and livestock gains on pasture, range conservationists and stockmen have reversed many of their early opinions. Bluestems, switchgrass, indiangrass, eastern gamagrass, Wright's sacaton, and giant wildrye are examples of grasses once thought unpalatable to cattle but now known to be preferred over many shorter ones that look more tender.

Buffalograss was long considered the most desirable grazing plant in the Great Plains. Experience has proved, however, that buffalograss not only is low in palatability but is a poor beef producer. Once used widely in range revegetation, it has largely been discarded for such purposes.

Kentucky bluegrass, the origin of which has puzzled many agrostologists and ecologists, is considered a native grass in classifying range condition. From observation and from facts now available, it is clear to the author of this chapter that the grass we call Kentucky bluegrass is native to both northern Eurasia and North America and, though an invader in some forests and in many grasslands, is a climax increaser in many northern ranges. Its value as a component of these ranges is appreciated by those who have seen it compare favorably with other pasture plants when treated equally.

## Native vs. Introduced Grasses

As the livestock herds increased in colonial times the need for more pasture and winter forage created a demand for hay and pasture seed. Having no knowledge of American grass sources, the colonists imported timothy, bluegrass, fescues, ryegrasses, red and white clovers, and other British forage plants including vetches and peas.

Since many of the north European forage plants failed in the deep South, native grasses prevailed there until the late 19th century when subtropical grasses were imported and successfully used.

When eastern settlers established farms in the Great Plains and the far West, they brought with them European pasture and hay plants and tried to use them instead of the native grasses, which they generally regarded as undesirable. There has been an unending search for the miracle grass, one that remains green all year and requires no water and that livestock could never exhaust by grazing. All the while the native grasses, which were being plowed or grazed out, came nearest to meeting these impossible requirements.

Crested wheatgrass, imported from western Asia, has been widely planted in the northern Great Plains and the Northwest since 1930. It was extended beyond its climatic range during favorable rainy periods and in the droughty 1950's most of the stands in the central Great Plains died out. Crested wheatgrass is still used extensively on deeper soils in the northern Great Plains and the Northwest.

Several other wheatgrasses, ryegrasses, and fescues became popular in the 1940's in northern climates and Kentucky 31 fescue had a warm reception in the middle South.

As is too often the case when new plants are not adequately tested for new soils and climates, some of these plants were disappointing. The favorite alfalfa and smooth brome mixture yielded to drought except on deep fertile soils where natural precipitation is favorable and on irrigated land.

Generally in the southern Great Plains and the Southwest, native grasses have been used most for seeding dry ranges. Lehmann lovegrass grown in the Southwest and buffelgrass and blue panicgrass in south Texas are introduced grasses that have proved valuable for providing grazing for a few years until replaced by equally productive native species.

SCS has been successful in selecting, breeding, and spreading the use of several native Great Plains grasses, including the bluestems, indiangrass, switchgrass, blue grama, sideoats grama, black grama, western wheatgrass, two species of trichloris, and many others.

## Fertilizing Rangelands

Interest in fertilizing ranges has ebbed and flowed for 30 years. SCS range conservationists have worked with experiment stations and producers to determine whether range fertilization is feasible. Except for a few situations, no economical method for fertilizing ranges has been found. In many instances, range plants have responded to fertilizers, particularly nitrogen and phosphorus, but the increased forage seldom has paid for the expenses involved. Some bad effects have been observed where animals concentrated on the fertilized area and reduced plant cover from fair to poor condition.

Producers have been shipping range animals to markets for more than 100 years. A few people fear that this continuous drain on nutrients without replenishment by artificial means will deplete the soils. Yet a large number of rundown ranges have been restored to a high state of grass production through proper grazing without the use of commercial fertilizer.

Fertilizer trials on rangeland, particularly in the subhumid bluestem belt, generally indicate some extra yields from phosphate and nitrate fertilizer. But usually costs of fertilizer and application have been greater than the value of additional forage produced.

Fertilization has been shown to pay on some California range sites where annual grasses and legumes make up the cover. There are many sites with shallow or otherwise unproductive soils, however, where fertilization has not paid off in California. SCS has started a survey to classify range sites that respond to fertilization.

It is evident that lime and fertilizer, at least, are needed and often profitable on tame pastures on many soils where introduced plants are used. Soil tests and local experience can guide the operator in determining fertilizer needs.

## Range in the Eastern United States

Until recently, no SCS range conservationists worked in the native grazing lands in the eastern part of the United States. This is a vast area containing 98 million acres of grazed woodland and other areas of native grass. Half of this is grazed woodland, a great multiple-use area where timber growing is the major use but livestock grazing is a widespread and important enterprise. Burned and cutover land also furnishes forage for domestic livestock, deer, and many small game animals.

SCS has assigned range conservationists to several States of the area and occasionally part-time help to others. These men, working with woodland conservationists, biologists, and agronomists, are perfecting conservation programs designed to improve the watersheds of the area for timber, livestock, and wildlife production.

## Future Forage, Feed, and Livestock Needs

Today more of the Nation's land is used for livestock production than for any other single purpose and most of it is in the care of private owners who have the responsibility for its conservation and improvement.

There are 633 million acres of grassland range and pasture and 245 million acres of forest and woodland also used for grazing. Of this total of 878 million acres, about 70 percent is privately owned. In addition 66 million acres of cropland is used only for pasture, and hay is produced from 63 million acres (USDA 1962b).

Range and pasture supply about a third of the feed units consumed by dairy cattle, three-fifths of the feed for beef cattle, and five-sixths for sheep and goats. About 10 million big game animals also obtain most of their forage from range and pasture (USDA 1962b).

The need for grassland and other forage-producing land in the United States is in sharp contrast to the expected requirements for cultivated cropland. Economists of USDA estimate that domestic use and export requirements of livestock products by 1980 will be 50 to 55 percent more than in 1959 (USDA 1962b). There is no surplus of grass today, and more, not less, will be needed in the future.

Fortunately, the increase can come largely through improvement of existing range and pasture. By and large, the Nation's grazing lands are producing now at no more than half their potential (table 3). If the trend of improvement already started in soil conservation districts can be continued and accelerated in the future, the increased forage can be produced on the present grassland acreage plus that to be established on land taken out of cultivation.

## Table 3.--Percent of privately owned range in each range-condition class

| Region | Excellent | Good | Fair | Poor |
|---|---|---|---|---|
| | *Pct.* | *Pct.* | *Pct.* | *Pct.* |
| West | 10 | 20 | 30 | 40 |
| Southern Great Plains | 5 | 15 | 40 | 40 |
| Northern Great Plains | 10 | 20 | 40 | 30 |
| Southeast | 10 | 20 | 45 | 25 |

Since the 1930's, 15 to 20 percent of the privately owned range in the West, Great Plains, and South has improved one condition class, which is equivalent to about 25 percent of its potential productivity.

The public land agencies report that large areas of the National forests and the Taylor Grazing and Indian lands are better grassed than in 1935.

These grassland improvements have paralleled a considerable expansion of beef cattle numbers. In 1920 there were over 12 million beef cows 2 years old and older, and more than 70 million total cattle. Although these numbers were down somewhat in 1940, by 1962 they had increased to 28 million beef cows and 99 million total cattle. Increases in beef cows have about offset the declining numbers of horses, sheep, and dairy cattle. In this 22-year period of rapid beef cattle expansion, substantial range and tame pasture improvement has taken place and feed grains have piled up in burdensome surpluses.

Greater skills in cropland farming, range and pasture management, plant breeding, and livestock breeding and herd management have contributed to the improving range, pasture, and animal production. In the soil conservation districts of the United States, more than 120 million acres of privately owned ranges and pastures are reported properly grazed. Nearly 19 million acres has been seeded to perennial range and pasture plants, 46 million acres of brush had control measures applied, and more than a half-million stock ponds have been built.

It can be safely predicted that the Nation will have sufficient grass and other forage and grains to produce the meat and other animal products the American public will need by 1980 and into the next century. To do this, however, will require the utmost use of total skills in conservation and animal husbandry.

# NEW PLANT MATERIALS FOR CONSERVATION FARMING AND RANCHING

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The recognition of the important role of grassland agriculture in soil and water conservation work created an unprecedented demand for seed and other planting materials of improved grasses and legumes.

When soil conservation began to be emphasized in the 1930's, adapted grasses and legumes were entirely lacking for some of the jobs to be done. Also, more and better planting materials of the few kinds in common use were needed by farmers and ranchers who began applying conservation treatment to their land. It was early apparent that the problem of planting materials would need special attention if grassland agriculture was to play its proper role in soil and water conservation.

In a widely cooperative program, 24 plant-materials centers were established by the Soil Conservation Service (SCS) and soon were engaged in the study and development of grasses and legumes for use in conservation work. Today there are 18 centers, each directing its work toward supplying the immediate needs of the area it serves. They are located at: Beltsville, Md.; Big Flats, N.Y.; Americus, Ga.; Arcadia, Fla.; Coffeeville, Miss.; Elsberry, Mo.; East Lansing, Mich.; Bismark, N. Dak.; Bridger, Mont.; Manhattan, Kans.; Spur, Tex.; Los Lunas, N. Mex.; Pullman, Wash.; Aberdeen, Idaho; Corvallis, Oreg.; Pleasanton, Calif.; Tucson, Ariz.; Kahului, Hawaii.

These plant-materials centers have three functions: (1) To assemble, evaluate, select, and increase grasses and legumes for use in soil and water conservation; (2) to determine reliable cultural and management methods for their use; and (3) to get proved materials into production by farmers and ranchers and by commercial growers.

Because of the urgency of finding new kinds of grasses and legumes and new cultural and management methods that could be reliably used on farm and ranch land, it was necessary to streamline the work. In less than 30 years, 30 new grasses and legumes, many of which are registered and certified, have been introduced into use. More than 50 million pounds of seed of these useful plants is on the market. None of these varieties could have been purchased 25 years ago.

The system used by the centers consists of five steps: (1) Grasses and legumes that may have value for one or more soil and water conservation jobs are gathered from many sources and carefully compared to find superior material; (2) promising material is increased, either for more precise comparison or for study of cultural methods; (3) the best material is tested in outlying locations called field-evaluation plantings that represent soil and climatic conditions not found at the center; (4) seed is distributed to soil conservation districts for planting on farms or ranches where performance under actual use can be studied; and (5) seed or plants are furnished to soil conservation districts which, in turn, select farmers to increase the material, preferably under certification. All these steps are taken in cooperation with State and Federal experiment stations and private research agencies who help assure that the highest standards are maintained in the work.

Materials for grassland agriculture as applied to soil and water conservation come from four sources: Foreign plant introduction, collection of superior material from the native grasslands, collection of naturalized alien grasses and legumes of unknown origin that have survived in out-of-the-way places, and strains from plant breeders. Although thousands of samples have already been assembled from these sources, collections are still being made. One plant-materials center may have brought together and screened as many as 20,000 samples and may be adding 100 or 200 new ones each year.

The mass of material that is collected for comparative evaluation must be tested rapidly yet objectively for the jobs required in conservation work. Samples are sorted into "use groups," each of which has a commonly known grass or legume to which the others can be compared. The use groups are based on the conservation job each grass or legume may do on farm, ranch, or watershed land. The comparisons are usually made in rod-row plantings at a plant-materials center. Records are made of the important features of promising plants, such as seedling vigor, outstanding vegetative quality, freedom from diseases and insects, absence of weedy possibilities, ground cover value, drought and winter hardiness, and yield of forage and seed. SCS conservationists and research workers in cooperating agencies often assist with these appraisals. Only a very few of the many thousands of samples studied by this comparison method are sufficiently valuable to be tested further. Selections are sometimes made of outstanding plants within a row of promising material.

A small increase of the most promising grass or legume from the row tests then is made at the plant-materials center.

If the indicated use of the new grass or legume is for a job in an area that has climate or soil conditions quite different from those at a center, it is put into a field-evaluation planting in that area. Such a planting is in plots, using conventional tillage and seeding equipment. A limited number of grasses and legumes are critically compared, the seedings are protected, and records are made.

Should the first test show that some cultural method needs to be worked out for the successful use of the new material, this is done at the center. This work may be related to time and method of planting, fertilizer requirements, compatibility in mixtures, irrigation water requirements, methods for producing and harvesting seed, and the like.

Once adaptation to climate and soils is known, cultural requirements are determined, and the grass or legume has shown real promise to advance some conservation job, it is put into field-scale plantings on farm and ranch land under actual use. SCS provides seed to soil conservation districts for this purpose. If the records of performance show that the new grass or legume is better than those in common use, they are used to propose it for general use. The plant materials center may then submit all the data from its tests to the cooperating experiment station for joint release. Often a new grass or legume is given a variety name and is accepted by the crop improvement association for certification. In such cases the adaptation, quality, use, and history of the grass or legume are known; it has a pedigree. This procedure adapts modern grassland agriculture to the objectives of the soil and water conservation program.

Growers in soil conservation districts make a needed contribution toward getting a new grass or legume into production with dispatch. Once a new variety or an entirely new plant is released (preferably with an agricultural experiment station), the plant-materials center maintains a foundation block of it. Seed or plants from this block are provided to soil conservation districts, where growers are selected and provided with technical assistance. Many new growers have been developed by this method.

During the time that new plants are being evaluated by the plant-materials centers, research workers in cooperating State and Federal agencies or in private research institutes may conduct numerous tests. Among these are studies of resistance to disease, breeding habits, forage quality, measured effectiveness for controlling runoff and erosion, effect on soil structure and fertility, and management requirements, when the grass is grazed or pastured. This supplemental research work gives farmers and ranchers added assurance that the new grass or legume has merit.

Following are selected, typical examples of results from the plant-materials work of SCS in every region in the country.

## Naturalized Alien Grasses and Legumes

Naturalized alien grasses and legumes are found in such out-of-the-way places as old permanent pastures, field borders, roadsides, railroad rights-of-way, and wasteland near seaports where ballast has been dumped. These plants had been accidentally introduced and had survived unnoticed until the soil and water conservation program got underway. The exact origin or date of their introduction is not known. Plant-materials specialists of SCS discover such plants or sometimes have them called to their attention by other soil conservationists or by workers in cooperating experiment stations. Regardless of origin or means of discovery, the plants are brought to the centers for study. The domestication of these aliens is an important source of good grasses and legumes, especially in the eastern half of the country.

BIRDSFOOT TREFOIL. The birdsfoot trefoil that is now a valuable pasture legume traces its introduction into our agriculture to 34 pounds of seed collected by a Soil Conservation Service CCC camp. This seed was collected in 1936 from an old pasture in the Hudson River Valley and was increased by the former Ithaca, N.Y., SCS Plant Materials Center. The first field planting was made in 1937 on low-fertility land in a land-utilization project nearby. The trefoil did so much better than other legumes that SCS conservationists recommended it for renovating pastures and encouraged farmers to harvest seed. The cooperating experiment station studied the material, made selections, and released the variety Empire. Meanwhile plant-materials centers in Iowa, Minnesota, and Missouri grew seed of this trefoil for field plantings in the Corn Belt. These field plantings verified its attributes as a pasture legume and its superior winter hardiness. Farmers are producing seed from stocks supplied by the centers.

KENTUCKY 31 TALL FESCUE. Once an alien of undetermined origin, Kentucky 31 tall fescue soon became widely used in the Southeast. Today there are at least 3 million acres of Kentucky 31 tall fescue, as compared to only one small field 21 years ago. The Kentucky experiment station called attention to a cool season grass that had been growing in a pasture on the Suiter farm in eastern Kentucky for 50 years. The SCS purchased 70 pounds of seed from this farm in 1941. It was increased by plant-materials centers formerly located in Kentucky and North Carolina. The seed was used in more than 600 field plantings in soil conservation districts throughout the Southeast, where its value for pasture, erosion control, and soil improvement was verified. Farmers in the districts produced seed, and by 1951 enough was available to plant 1-1/4 million acres. Plant-materials centers in the Corn Belt and Northeast grew seed and made field plantings. This fescue proved to be widely adapted and is now in use in the southern

parts of these States as well as in the Southeast.

CROWNVETCH. Crownvetch escaped from cultivated gardens and became naturalized in several places in the Corn Belt and the Northeast. Its dense mat of attractive vegetation, strong fleshy rhizomes, and adaptation to permeable soils low in nitrogen suggested use for stabilizing highway embankments, dikes, streambanks, and strip mine spoil banks. Several samples of crownvetch were brought into the former SCS Ames, Iowa, Plant Materials Center in 1938 for study and increase. A selection characterized by vigorous seedlings and high production was jointly released by SCS and the experiment station as the variety Emerald. Certified seed is being produced in soil conservation districts. Field plantings on farms show specific adaptation to kinds of soil, and value for pasture, where alfalfa or Ladino clover cannot be used. The Chemung variety was developed by the Big Flats Plant Materials Center in New York by a similar series of tests and evaluations. The first collections were made in 1935. Chemung surpassed all others in the tests in seedling vigor, rate of spread, and growth. It is grown under certification in New York, Vermont, and Ohio.

PENSACOLA BAHIAGRASS. An alien grass that is a leader in grassland agriculture in the Southeast was first noticed in 1939 as having potential for converting eroded cropland to permanent pasture. Two burlap bags of sprigs of bahiagrass were dug near Pensacola, Fla., in the spring of 1940. They were taken to the SCS Americus Plant Materials Center in Georgia for study and increase. Limited distribution for field plantings in soil conservation districts was begun in 1942. These plantings showed that the grass produces a dense sod on sandy hill soils of relatively low fertility, is easily maintained, and produces good forage. This strain was named Pensacola bahiagrass and released by the Florida Agricultural Experiment Station in 1944 (Hanson 1959).

Pensacola bahiagrass proved to be sensitive to low temperatures. In the hope of finding a more cold-hardy strain, 16 additional collections of naturalized material were made in the Southeast and 17 were obtained by introduction. Six distinct types are recognized, and plant breeders have produced two new lines (Burton 1946). These types vary in cold tolerance, but observations on performance in hundreds of field plantings show the adaptation of each and make it possible to use bahiagrass in most of the Southeast. Farmers in the districts produce seed. As a result, there are already more than 5 million acres of this grass in the Southeast.

SOUTHERN-TYPE BROMES. The rapid spread of smooth brome in the Corn Belt and Northeast is in no small measure the result of hundreds of field plantings in soil conservation districts using seed produced by plant-materials centers. The superior performance of the southern-type bromes over imported material and old standard material for hay and pasture was evident from the first. All the strains of the southern type were obtained from old pastures in the 1930's by personnel of SCS plant-materials centers or by agricultural experiment stations (Thomas et al. 1958). They were later given variety names, and the most prominent among them are Achenbach, Elsberry, Fischer, and Lincoln. The early spring growth and dense sod make these southern-type bromes especially well suited for rotation pastures. Mixtures of these bromes with alfalfa or Ladino white clover provide good "big bite" pastures to replace the older and less productive bluegrass-clover pastures.

KING RANCH YELLOW BLUESTEM. King Ranch yellow bluestem gets its name from the ranch where it was discovered in 1939 by an employee of the SCS San Antonio, Tex., Plant Materials Center. Its origin is unknown, but at the time it was found employees of the ranch stated it had been there for 35 years (Webster and Foster 1949). Seed was collected by hand in 1939 and taken to the center for comparison with other bluestems and similar grasses. It was outstanding; therefore, it was increased to use in field plantings. These plantings show that King Ranch yellow bluestem has wide adaptation to climate and soils in the southern Great Plains, is easy to establish, is vigorous, makes good pasture, has an extensive root system, and produces good yields of seed. It has many uses in soil and water conservation work. It is widely used for pasture, grass waterways, stabilizing detention dams and other watershed structures, and to some extent for rangeland seedings. Seed is easy to produce under cultivation.

CUCAMONGA CALIFORNIA BROME. Cucamonga California, a selection from a collection of a naturalized alien grass made in 1939 in southern California, was studied by the SCS plant materials center at Pleasanton and the former San Fernando center. The seedling vigor, rapid growth, early maturity, and reseeding characteristics suggested its use as a cover crop in vineyards on sandy soil where winter winds cause severe erosion and where a plant with a low water requirement was especially desired. Its value as a reseeding annual cover crop in dryland orchards, for seedings to protect steep land after brush burns, and for stabilizing earth-fill dams, road cuts, and other exposed areas is evident from field plantings. The variety was cooperatively released by SCS and the California Agricultural Experiment Station in 1949.

GARRISON CREEPING FOXTAIL. Garrison creeping foxtail was found growing around a pothole near Max, N. Dak. was probably brought in by early homesteaders. Seed was taken to the SCS plant-materials center at Bismarck in 1950, where it was increased. Field plantings in soil conservation districts in the northern Great Plains demonstrate its value for pasture and hay on wetlands, swampy areas, and mountain meadows where unproductive sedges

and rushes commonly grow. Garrison creeping foxtail produces good yields of high-quality forage where other grasses fail because the land is inundated for several weeks. When grown on such areas it provides spring nesting places for waterfowl. After it was named Garrison, for a place in North Dakota where it was first found, the variety was cooperatively released for certification by SCS and the Wyoming Agricultural Experiment Station. Meanwhile seed was increased by the SCS plant materials center at Elsberry, Mo., for use in field trials that are extending its use in the Corn Belt States.

## Domesticated Native Grasses

The discovery of the superior value of native prairie grasses over common commercial grasses for seeding severely eroded land, rangeland in poor condition, and waterways--especially in the Great Plains and West--and the development of varieties of several of them is an epoch in grassland agriculture in America.

The urgency for seeding large areas for erosion control and range improvement suggested collecting and using seed from the native prairies. The native prairies were extensive, and the grasses that grew there developed under continuous use by native grazing animals for centuries. The early seed harvests were fraught with difficulties. Ordinary machinery required major modifications and areas that produced enough good seed to warrant harvest had to be carefully selected. The personnel of SCS plant-materials centers assisted with both jobs. Improvements and adjustments were made in machinery and efficiency was increased until 3 million pounds of seed was collected in the record year 1948.

Two handicaps were encountered when using grasses collected from the native prairies. The yield and quality of seed varied from year to year, and seed collected in one area and then planted in another often resulted in poor performance. Comparisons of species collected from different sources and grown together in plant materials centers verified the differences in performance and showed the advantages of growing seed under cultivation on good land. These geographical strains or locally adapted variants are called ecotypes. They are evaluated first in plant-materials centers, then in field-evaluation plantings, and finally in field plantings on farms and ranches to determine where each ecotype is best adapted. These tests are the basis of the principle that an ecotype performs satisfactorily in an area no more than 250 to 300 miles north and no more than 150 to 200 miles south of its origin. When movement is east or west, the safe distances may be greater or less, depending on climate and elevation.

Ecotypes of known adaptation, after some selection of superior plants, are assigned variety names and then grown under cultivation from foundation stock maintained at the plant-materials centers. The varieties developed by the centers in the Great Plains are: Blackwell and Grenville switchgrass; El Reno, Vaughn, Uvalde, and Pierre sideoats grama; Cheyenne indiangrass; Marfa green spangletop; and Odessa plains bristlegrass. More than 5,000 acres of these varieties are in production, most of them under irrigation. Varieties of switchgrass, sideoats grama, indiangrass, green needlegrass, and big and little bluestem have also been developed by cooperating State and Federal experiment stations, and about 5,000 acres of them are in seed production. Enough seed of all varieties is being grown to plant one-third million acres annually, but the supply is still inadequate to meet planned needs.

BLACKWELL SWITCHGRASS. The development of Blackwell switchgrass is typical of how a native prairie grass is brought into widespread use for soil conservation. The variety traces to a single plant collected in 1934 near Blackwell, Okla. Studies at the SCS plant-materials center at Manhattan, Kans., comparing it with many other ecotypes disclosed its superior performance for leafiness, forage and seed production, and resistance to plant diseases. Field plantings in the eastern Great Plains and in the Corn Belt and Northeast demonstrated wide adaptability for a variety of soil conservation uses. The principal use is for seeding low-capability cropland and poor condition rangeland to grass, but it is also used for pastures, waterways, and for stabilizing dune sands along the Atlantic Coast.

The variety was cooperatively released by SCS and the Kansas Agricultural Experiment Station in 1944. Farmers grow good seed crops of Blackwell switchgrass under cultivation from foundation stocks maintained by the plant-materials centers.

SODAR STREAMBANK WHEATGRASS. Sodar streambank wheatgrass is typical of a native grass that has special uses in soil conservation work. It was first noticed by a county agent as a sod-forming grass in a dryland area in Oregon where bunch grasses predominate. It and 10 other collections were compared in the plant-materials centers in the Northwest where Sodar was selected for its seedling vigor and its persistent, open, and low-growing sod. Field plantings demonstrated its value for stabilizing irrigation-canal banks, preventing erosion on light soils, making good sod on small airplane landing strips, and stabilizing saline-sodic soils that occur on some military installations. Once established it persists, even in low rainfall areas. Plant-materials centers in the West have domesticated several other grasses. Farmers in that region are growing seed of Bromar mountain brome, Sherman big bluegrass, Whitmar beardless, Primar slender, and Sodar streambank wheatgrasses. More than one-half million pounds of seed are produced annually.

## Foreign Plant Introductions

Foreign plant introductions are a valuable source of grasses and legumes for conservation work. They

had been for many years a valuable source of germ plasm for field crops and horticultural plants, but introduction of materials to use in grassland agriculture was given impetus by the soil and water conservation program. Study of introductions in plant-materials centers and in field plantings on farms led to the widespread use of many grasses and legumes previously unknown or grown to a limited extent.

MANCHAR SMOOTH BROME. Manchar smooth brome was introduced from Manchuria in 1935. It was selected from 120 samples of smooth brome by the SCS plant-materials center at Pullman, Wash., as being especially well suited to use in alfalfa-grass mixtures. It is superior to the southern-type brome for use in alfalfa-grass mixtures in the Northwest because of its mild sod-forming characteristic and its growth in late spring and early summer. Forage quality is good, the leaves are carried high on the stems, and seed production is excellent for a high-quality grass. It was named and cooperatively released in 1943, and about 2 million pounds of seed are produced annually.

WHEATGRASSES FROM RUSSIA. Greenar intermediate wheatgrass, Topar pubescent wheatgrass, Alkar and Largo tall wheatgrass, and Siberian wheatgrass, which are in common use in the West, are the result of studying introductions in plant-materials centers and in field plantings. Samples of each grass were received from Russia in 1934. The best were chosen and improved by selection, and their adaptation to land-capability classes was determined.

Each has unique characteristics not possessed by common species of wheatgrass long used in agriculture. For example, Alkar and Largo tall wheatgrass are exceptionally well adapted to saline and alkali soils so common in the West. Their yield per acre is high, forage quality is good, and their heavy root systems help correct poor soil conditions. Greenar intermediate and Topar pubescent wheatgrasses supplement other grasses used for pasture under dryland conditions in the Northwest because they provide green feed into the summer months after other pasture grasses are dormant. Topar pubescent wheatgrass is adapted to lower land-capability sites than is Greenar and is an ideal grass for waterways on land in semiarid areas. Siberian wheatgrass produces better yields than crested wheatgrass on coarse soils and in years when soil moisture is below average.

LOVEGRASSES FROM AFRICA. Lehmann and Boer lovegrass are superior to other grasses for seeding rangeland in the Southwest. They were introduced from South Africa, where their qualities for erosion control, adaptation to low-capability land, and forage value were recognized. They were tested and increased by the SCS plant-materials center at Tucson, Ariz., and seed is grown by farmers. Weeping lovegrass was introduced at the same time. It is not so drought tolerant, but tests in the southern Great Plains, the Southeast, and in the Northeast demonstrated its value for stabilizing eroded areas and sandy soils, and for improving soils with heavy clay pans. It has an extensive root system.

BLUE PANICGRASS. Blue panicgrass, introduced earlier, did not show promise until an introduction from Australia was obtained in 1934. Tests of this introduction by plant-materials centers in the southern Great Plains and the West led to the present extensive use for seeding brush-infested rangeland that is cleared by root plowing.

BUFFELGRASS. Buffelgrass is used for seeding cleared brushland on sandy soils in Texas. It was introduced from South Africa in 1946 and tested and released by the SCS San Antonio Plant Materials Center and is now produced commercially. Its salient features are good seedling vigor, drought tolerance, ability to grow rapidly from early spring through the hot summer months, and high seed production. The use of introduced buffelgrass is spreading in low rainfall areas in Hawaii and Puerto Rico.

PANGOLAGRASS. Pangolagrass was introduced from South Africa in 1935 and released by the Florida Agricultural Experiment Station in 1944. Its good forage quality and excellent ground cover are an ideal combination for conservation work. It does not produce seed; therefore, plant-materials centers in Florida and Georgia grow and distribute vegetative material from which sod banks are established in soil conservation districts. Farmers mow or use a field chopper to collect the surface runners when the grass is in the hay stage. This material is then scattered over a prepared seedbed on the field to be planted. A light disking anchors the material in the soil and partially covers it. The 500,000 acres of pangolagrass plantings in Florida trace to these sod banks. Similar methods for getting this grass into use are used in Hawaii and Puerto Rico with equally good results.

BALL CLOVER. Ball clover fills a need for a reliable winter annual legume in pastures and for cover crops in the Southeast. An introduction from Turkey has been evaluated in plant-materials centers and field plantings since 1949. Outstanding characteristics as compared to crimson clover are better production in late winter and early spring and more reliable reseeding, even in heavy sod, on thin sandy soils.

LANA WOOLLYPOD VETCH. A versatile winter annual reseeding legume with many uses for soil and water conservation is Lana woollypod vetch. It was developed by the SCS plant-materials center at Pleasanton, Calif. It was first introduced from Turkey in 1937, but no use was found for it until it was seeded with a dozen other legumes in a field-evaluation planting on an annual rangeland in California in 1946. It is the most consistent of all the legumes in reseeding and is superior to others for ground cover and for increasing forage production. The first field plantings in soil conservation districts were made in 1951. Broad adaptation to soils, good protection to banks along waterways, food for upland gamebirds, and adaptation for use as a cover crop in orchards are

added attributes observed in these plantings. Its use as a reliable legume is increasing rapidly on 5 million acres of foothill rangeland and for cover cropping in orchards.

LATAR ORCHARDGRASS. Latar orchardgrass was discovered by the Pullman, Wash., Plant Materials Center. It is a selection from an orchardgrass introduction from the U.S.S.R. in 1934. Its singular value for use in alfalfa-grass mixtures for hay, pasture, and soil improvement is clearly evident in comparative evaluations of a large number of domestic strains and foreign introductions. Chief among these are that the best hay stage coincides with that of alfalfa, the yield of forage and roots is equal to that of other orchardgrasses, and forage quality is exceptional. Farmers where field plantings were first made for pasture quickly noticed the superior quality. This was verified by research workers in the Washington Agricultural Experiment Station who found that its lignin content is significantly lower than that of other varieties and that digestibility is the highest of any orchardgrass under test. Pound for pound and ton for ton, Latar orchardgrass is 10 percent higher in digestible nutrients than common orchardgrass. Farmers in the Northwest began growing seed after the variety was cooperatively released in 1957, and enough seed is being produced--mostly on irrigated land--to plant 80,000 acres annually.

SVALOFS SLEIPNER FIELD BROME. Tests in plant-materials centers and numerous field plantings are increasing the use of Svalofs Sleipner field brome in the Corn Belt and Northeast. It proves to be an excellent winter cover crop in nonirrigated orchards and for land where corn, soybeans, tobacco, and vegetables are grown. Svalofs Sleipner field brome was introduced from Sweden in the early 1930's. The former Ithaca Plant Materials Center in New York began increasing it in 1939, and increases by centers in the Corn Belt began in 1954. Rapid growth to a good soddy ground cover in the early fall, winter hardiness, exceptionally high root production, and ability to reseed characterize this grass. The winter annual grasses and grains with which it is compared fail in one or more of these respects. Field plantings show that Svalofs Sleipner field brome can be pastured by livestock and poultry in the early fall and spring and plantings are grazed by migratory geese.

## Cultural Methods

Many of the new plants for grassland agriculture and soil conservation are in use because new ways and means are available for harvesting and planting seed and for managing established stands. Seed of many native grasses and some introduced species have long, fluffy appendages, are encased in burs, or shatter badly when nearly ripe, making them difficult to harvest and plant with ordinary farm machinery. Many sites that require a protective cover have severe limitations that require special treatment to establish grasses and legumes. Machinery is now available to harvest, process, and seed many of these plants and new methods are in use for establishing them. Facilitating studies by SCS plant-materials centers have contributed substantially to these improvements.

Seed of native grasses, whether on the prairies or in cultivated fields, is harvested with binders and combines that have modified reels, sickle bars, cylinders, straw shakers, and other attachments. Vacuum harvesters are used for some of them. These modifications are the result of trial, error, and ingenuity of SCS personnel, soil conservation district supervisors, and local machine shops. Even so, harvested seed is difficult to handle unless it is processed with modified hammermills before cleaning. Processing removes objectionable appendages, makes such seed acceptable for planting, and greatly improves the quality. The method is the result of studies made simultaneously by SCS plant materials centers at Mandan, N. Dak., and Pullman, Wash. No single effort has had a greater influence on getting good new plants into extensive use, especially in the Great Plains and West, than has this processing method.

The use of special drills and planters by soil conservation districts has had a marked influence in getting acceptance and widespread use of new grasses. Special drills are used that have a combination of cottonseed boxes to plant the light, fluffy seeds of grama grasses and bluestems and vegetable seed boxes to plant the extremely small seeds of lovegrass. This combination of seed boxes along with disk openers and depth regulators makes it possible to drill two widely different kinds of seed simultaneously and with precision. The first such drill was designed and tested jointly by the personnel of the former Woodward, Okla., Plant Materials Center and the Southern Great Plains Field Station at Amarillo, Tex. The early model was gradually improved following its use in field evaluation plantings. The improved models are now manufactured commercially, and more than 500 of them are used in soil conservation districts in the Great Plains States. Machines for digging planting sprigs of bermudagrass were developed in the same way and facilitate vegetating waterways. They are widely used in the southern Great Plains and the Southeast.

A cultural method for successfully establishing perennial grasses on sites subject to severe wind erosion resulted from tests made in field evaluation plantings in the Great Plains. Slow to emerge and to develop into strong seedlings, hence easily dislodged by wind if seeded directly, without a surface cover the perennial native grasses are planted in the stubble or litter of a prior crop of sorghum. The stubble and litter from the sorghum protect against wind and water erosion, keep moisture near the soil surface, and suppress weeds. The same principle is used to establish vegeta-

tion on watershed structures, but here the residue is often applied as a mulch.

Alternate-row seedings of grasses and legumes have advantages in conservation work. They make it possible to use legume-grass combinations that often failed or produced stands of incorrect proportion because one of the plants is more aggressive than the other, especially during establishment. The method was developed by the Pullman, Wash., Plant Materials Center and is widely accepted. Hundreds of field plantings on farms demonstrate the advantage of the method and no disadvantages have been found. Even ordinary grain drills without grass seed attachments can be used by adapting the rice-hull-dilution method developed by the Pleasanton, Calif., Plant Materials Center. Cardboard dividers are inserted in the grain box to make separate compartments over the feed cups. Then seeds of the grass and the legume are separately mixed with rice hulls to get equal volumes of planting material and the two mixtures placed in alternate compartments in the drill. One setting of the drill plants both seeds at the desired rate. The method has special merit when seeding birdsfoot trefoil and grass but is equally effective with many other grass-legume combinations.

Much of the land requiring treatment for conservation in the Southwest is in an arid climate with extremely wide variations in precipitation from year to year. This makes it difficult to establish new grasses on low-capability farmland and rangeland in poor condition. A combination of a pitting disk and a packer wheel seeder that was developed by the SCS plant-materials center at Tuscon, Ariz., substantially increases the success of such seedings. The pitting disk reduces competing weedy annual grasses and concentrates water in the pits; the seeder places seeds in and around the newly made weed-free depression.

Ranchers in soil conservation districts in California are using a combination of new plants, new cultural techniques, and a new management method that increases meat production as much as 66 percent by extending the grazing season to 6 months instead of the usual 6 weeks. This method of improving foothill rangelands is the result of studies in a field evaluation planting by the Pleasanton, Calif., Plant Materials Center. Soil surveyors, range conservationists, and agronomists of the SCS and the cooperating agricultural experiment stations assisted with the work.

Perennial hardinggrass is the key to lengthening the grazing season. The studies show that it can be established if seeded on sites that have soil with a moisture-retaining layer about 24 inches below the surface. A prior crop of sudangrass is grown on the land to reduce the volunteering resident annual grasses and provide summer feed. A good seedbed is prepared, and hardinggrass is planted in the fall. Annual applications of 16-20-0 fertilizer are used after hardinggrass is established.

The winter annual grasses on another portion of the ranch are fertilized with a combination of nitrogen and phosphorus. Two hundred pounds of 16-20-0 fertilizer triple the yield and double the usual 6-weeks grazing season of the annual grasses by bringing them on much earlier. The result is 5.2 animal-unit months of grazing per acre as compared with only 1.6 without fertilizer. Nowhere in the West do fertilizers give such a large and consistent response on rangelands, but the studies show that the nitrogen-phosphorus combination must be used, not one or the other.

Grazing the hardinggrass, the fertilized annual grass, and the unfertilized part of the ranch in rotation is the secret to high and consistent livestock production. The perennial hardinggrass is ready to graze first and is pastured from December 15 to February 1. The fertilized annual grass is then ready and is grazed for the next 6 weeks. The herd is moved to unfertilized range for an equal length of time and finished off on the hardinggrass the last 6 weeks because it remains green after annual grasses are mature and dry.

A novel and inexpensive method for making good waterways, stabilizing large gullies, and building grass flumes is the green-hay method perfected by the SCS plant-materials center formerly operating at Ames, Iowa. Reed canarygrass is mowed close to the ground between June 1 and September 30. The hay is taken to the gully or other waterway, spread over the ground, and pressed in with a dull spade or board, or tramped in to a depth of about 2 inches. Only a part of the stem needs to be under water or in moist soil. Results in field plantings since 1947 demonstrate the superiority of the green-hay method over seeding. "Sod banks" are maintained in some soil conservation districts using the Ioreed variety supplied by the Elsberry, Mo., Plant Materials Center.

New grasses and legumes are effectively used on large areas of low-capability land because precise cultural methods are worked out by plant-materials centers and cooperating experiment stations. The methods for regrassing saline and saline-sodic soils in the more arid parts of the West provide an example. The areas of such soils are often extensive and an integral part of the farm or ranch or are in some critical area, but they support only poor quality grasses and salt-tolerant shrubs. The cover is often so sparse that wind and water erosion are common.

## Establishing grass on saline and alkali land

Scarcity of irrigation water is often a major problem in treating saline and alkali land in low-rainfall areas. But there are grasses and cultural methods that provide good ground cover and forage with limited water. Wind erosion from such land near a large military airfield in the West was severe. A field-evaluation planting was established in cooperation with the U.S. Navy and the Nevada Agricultural Experiment Station.

A sparse growth of brush was cleared, and the land was leveled to irrigation grade. Results from a study of ways to obtain good ground cover, even when soil tests indicated that 7.5 tons of gypsum would be required to reduce exchangeable sodium in the surface 6 inches of soil to 15 percent, showed that Willcox alkali sacaton or Sodar streambank wheatgrass can be established and provide a dense ground cover if careful attention is given to frequent light irrigations following seeding to keep the surface moist and move the salts downward in the soil profile. If this is done and nitrogen fertilizer is applied, no other treatment is needed.

Willcox alkali sacaton is a summer-growing grass and requires irrigation every 5 days for 6 weeks after seeding. A total of 36 acre-inches of irrigation water is needed. Sodar streambank wheatgrass is a cool-season grass, is planted in the fall, and must be irrigated in the same way but less frequently. Fifteen acre-inches of water is required. During the first full growing season both grasses are irrigated at 3- to 4-week intervals, using a total of about 25 acre-inches of water. After that the stands provide a dense cover and remain green with only four irrigations at 6-week intervals, a total of about 15 acre-inches of water.

Other grasses adapted to this cultural method on such soil are Alkar tall wheatgrass and basin wildrye. They and Willcox alkali sacaton are good forage plants that yield from 1 to 3 or 4 tons per acre, depending on the amount of irrigation water available and how they are fertilized.

The directors of the Los Banos Soil Conservation District have saline-alkali land typical of 500,000 acres in the San Joaquin Valley in California. The soils are fine textured, internal drainage is poor, the water table is high, and the grass and weeds that grow naturally are of poor quality and extremely low in yield. The directors asked SCS to establish a field-evaluation planting to learn how to produce good pasture. Good water from wells is available for irrigation, but drainage ditches are not feasible on this land. Several corrective measures have been tried, but the best and most feasible are leveling the land, constructing rice levees, working 3 tons of gypsum into the soil, and ponding water and flushing it off. These corrective measures are applied in the summer, the land is left to dry, a seedbed is prepared, and pasture seedings are made in the fall. The best grass of 17 and the best legume of 3 that have been tried is a combination of Goar tall fescue and Los Banos narrowleaf birdsfoot trefoil. When such a pasture is correctly fertilized and irrigated, the dairy herd that grazes it produces an average of about 10,000 pounds of milk per acre. Local farmers state that this is 25 times more than the land produced before treatment.

## Farmer and Rancher Acceptance

Knowing the forage quality of new grasses or grass-legume combinations introduced to agriculture for conservation work advances acceptance by farmers or ranchers who use them for feed as well as for treating their land. Cooperating experiment stations often provide this information.

The grazing trials conducted by the Washington Agricultural Experiment Station with beef cattle on pastures containing Greenar intermediate wheatgrass established by the SCS Pullman Plant Materials Center showed this new grass to be equal in beef production to common grasses and superior to some. This same station did the laboratory tests and digestibility trials that substantiated the superior merits of the new Latar orchardgrass as feed.

Cooperative feeding trials with Alkar tall wheatgrass at the Eastern Oregon Branch Experiment Station established the quality of this new introduction, and the result is responsible for its acceptance. Alkar tall wheatgrass appeared quite coarse, and farmers and ranchers questioned its value for forage. Twenty grasses were grown in the field-evaluation planting maintained at the station. Each grass was fed free choice to sheep in every possible combination with four of the other grasses for 2 years, and records were kept of the amounts consumed. The new tall wheatgrass was as palatable as tall fescue but much higher in production per acre; in fact, it produced more forage per acre than any grass in the test. Since then field plantings have demonstrated its acceptance by livestock when grazed or fed as hay or silage as well as its unique adaptation to saline and alkali soils.

The Idaho Agricultural Experiment Station, using crops grown by the SCS Aberdeen Plant Materials Center, conducted feeding trials comparing alfalfa-grass hay with alfalfa hay. They proved the equal value of the two and give added confidence to farmers who use the mixture for conservation seedings and forage.

## Seed Production in Soil Conservation Districts

If grassland agriculture as used in conservation work succeeds, seed supplies of new and improved grasses and legumes must be available in quantity. Farmers in soil conservation districts became producers as the result of SCS policy to provide the districts with foundation seed of new materials grown by the centers and with technical assistance in producing. The districts are responsible for making supplies available. They use techniques worked out at plant-materials centers, some of which are the result of cooperative work between the centers and research agencies. Two examples are typical of results throughout the country.

The desire to conserve irrigation water led to the formation of one soil conservation district in Idaho, and grass-seed production promptly became an established enterprise in the district, largely because

the Aberdeen Plant Materials Center showed that good seed crops of grass could be grown with one-third less water than irrigated row crops. Although none of the farmers had ever grown grass seed before, 75 growers now produce 1/2 million pounds of seed annually, enough to plant 80,000 acres. The total crop has a value of 1/4 million dollars, and five new processing plants have been established in the community.

Results obtained by plant-materials centers and by farmers who now grow seed under cultivation in soil conservation districts are responsible for a major change in seed production in the southern Great Plains. In 1960 more than 1-1/2 million pounds of seed of new varieties of native grasses were grown, and only 400,000 pounds of seed of introduced grasses. Five years before this only 28,000 pounds of five species of native grasses and 885,000 pounds of seven exotic species were produced. In the Great Plains as a whole, 3 to 4 million pounds of named varieties of native grasses are now produced annually under cultivation, much of it under irrigation.

Starting with none before 1950, there were 67 growers of Empire birdsfoot trefoil in 27 soil conservation districts in Iowa in 1958. All these growers obtained foundation seed through their districts from the plant-materials centers. The spread in the use of trefoil on land where alfalfa is not adapted in the Corn Belt is largely due to the efforts of these growers.

Similar production of seed by farmers in districts in all sections of the country makes possible the rapid expansion in acres converted to grass for conservation purposes. The demand continues for new and better materials and for improved methods of culturing and managing them as refinements in conservation work are made and new needs for treating farm, ranch, and watershed land are discovered.

Foundation seed stock at a plant-materials center.

## LITERATURE CITED


Burton, G. W.
1946. Bahiagrass types. J. Amer. Soc. Agron. 38: 273-281.

Canfield, R. H.
1948. Perennial grass composition as an indicator of condition of southwestern mixed grass ranges. Ecol. 29: 190-204.

Chapline, W. R.
1948. Grazing on range lands. In Grass, Yearbook of Agriculture 1948, pp. 212-216. U.S. Dept. Agr.

Costello, D. F., and Turner, G. T.
1944. Judging condition and utilization of shortgrass ranges on the central Great Plains. U.S. Dept. Agr., Farmers' Bul. 1949, 21 pp., illus.

Dyksterhuis, E. J.
1949. Condition and management of rangeland based on quantitative ecology. J. Range Mangt. 2: 104-115.

Ellison, Lincoln
1949. The ecological basis for judging condition and trend of mountain range land. J. Forestry 47: 787-795.

__________ and Croft, A. R.
1944. Principles and indicators for judging condition and trend of high range watersheds. U.S. Dept. Agr., Intermountain Forest and Range Expt. Sta. Res. Paper 6, 65 pp.

Hanson, A. A.
1959. Grass varieties in the United States. U.S. Dept. Agr., Agr. Hbk. 170, 72 pp.

Humphrey, R. R.
1945. Some fundamentals of the classification of range condition. J. Forestry 43: 646-647.
1947. Range forage evaluation by the range condition method. J. Forestry 47: 10-16.
1949. Field comments on the range condition method of forage survey. J. Range Mangt. 2: 1-10.

Osborn, Ben.
1952. Storing rainfall at the grass roots. J. Range Mangt. 5: 408-414.
1953. Field measurements of soil splash to evaluate ground cover. J. Soil and Water Conserv. 8: 255-260, 266.
1954a. Soil splash by raindrop impact on bare soils. J. Soil and Water Conserv. 9: 33-38, 43, 49.
1954b. Effectiveness of cover in reducing soil splash by raindrop impact. J. Soil and Water Conserv. 9: 70-76.

Reid, E. H., and Pickford, G. D.
1946. Judging mountain meadow range condition in eastern Oregon and eastern Washington. U.S. Dept. Agr., C. 748, 31 pp., illus.

Renner, F. G., and Johnson, E. A.
1942. Improving range conditions for wartime livestock production. U.S. Dept. Agr., Farmers' Bul. 1921, 18 pp., illus.

Stoddart, L. A., and Smith, Arthur D.
1943. Range management. McGraw-Hill Co., New York. 197 pp., illus.
1962 a. Basic statistics of the National Inventory of Soil and Water Conservation Needs. U.S. Dept. Agr., Statis. Bul. 317, 164 pp.
1962b. Land and water resources, a policy guide. U.S. Dept. Agr., Washington, D.C. 73 pp.

Webster, C. B., and Foster, David H.
1949. King Ranch bluestem. U.S. Soil Conserv. Serv., Ft. Worth, Tex. Processed, 14 pp.

Wooten, H. H., Gertel, Karl, and Pendleton, W. C.
1962. Major uses of land and water in the United States. U.S. Dept. Agr., Agr. Econ. Rpt. 13, 54 pp.

# PUBLICATIONS ON GRASSES AND LEGUMES BY THE SOIL CONSERVATION SERVICE

The story of grass in conservation is reflected in the publications of the U.S. Department of Agriculture. The contributions of the Soil Conservation Service have had a prominent place in this record from the time it became a part of the Department.

This section brings together two lists of publications on grasses and legumes by SCS workers. The first, a chronological list of USDA and SCS Washington office publications, is complete. It is neither practical nor appropriate to attempt to present here a complete list of the even larger number of non-USDA publications in which SCS had a part. These are publications issued by regional or State SCS offices, by the State experiment stations and land grant colleges, in technical journals and popular magazines, or as ephemeral documents for use within SCS. Some of the technical journal articles and State bulletins make up the second list.

The Department of Agriculture issued two publications--one on tame pastures and one on rangeland--that summarized the knowledge of grassland about the time the national soil conservation program was getting under way:

1934. Semple, A. T., H. N. Vinall, C. R. Enlow, and T. E. Woodward. A pasture handbook. Misc. Pub. 194. 89 pp., illus.

1936. Various authors. The western range. Sen. Doc. 199, 74th Cong., 2nd sess. 620 pp., illus. Prepared by the Forest Service, with cooperation of other agencies of the Department of Agriculture, in response to Senate Resolution 289.

These two publications were principal references for grassland workers for the ensuing decade and now are recognized as classics in their field. Some of the authors soon joined the new Soil Conservation Service and strongly influenced the development of grassland technology as a part of soil and water conservation.

## Chronology of USDA publications


1936

Carrier, Lyman. Grass in soil erosion control. SCS-TP-4. 15 pp.

Fults, Jess L. Blue grama grass for erosion control and range reseeding in the Great Plains and a method of obtaining seed in large lots. C. 402. 8 pp., illus.

Uhland, R. E. The use of bluegrass in the control of soil erosion. Farmers' Bul. 1760. 12 pp., illus.

1937

Musgrave, G. W., and R. A. Norton. Soil and water conservation investigations at the Soil Conservation Experiment Station, Missouri Valley Loess Region, Clarinda, Iowa; Progress Report 1931-35. Tech. Bul. 558. 182 pp., illus.

Rowalt, E. M. Soil and water conservation in the Pacific Northwest. Farmers' Bul. 1773. 59 pp., illus.

1938

Enlow, C. R., and G. W. Musgrave. Grass and other thick-growing vegetation in erosion control. In Soils and men, Yearbook of Agriculture 1938, pp. 615-633.

Rowalt, E. M. Soil defense in the South. Farmers' Bul. 1809. 64 pp., illus.

1939

Bailey, R. Y. Kudzu for erosion control in the Southeast. Farmers' Bul. 1840. 32 pp., illus.

Cardon, P. V., W. R. Chapline, T. E. Woodward, E. W. McComas, and C. R. Enlow.* Pasture and range in livestock feeding. In Food and life, Yearbook of Agriculture 1939, pp. 925-955.

Davison, Verne E. Protecting field borders. L. 188. 8 pp., illus.

Enlow, C. R. Review and discussion of literature pertinent to crop rotations for erodible soils. C. 559. 51 pp., illus.

Franklin, Sydney. Mulching to establish vegetation on eroded areas of the Southeast. L. 190. 8 pp., illus.

Hoover, M. M. Native and adapted grasses for conservation of soil and moisture in the Great Plains and Western States. Farmers' Bul. 1812. 43 pp., illus.

Pieters, A. J. The annual lespedezas as forage and soil-conserving crops. C. 536. 56 pp., illus.

__________ Lespedeza sericea and other perennial lespedezas for forage and soil conservation. C. 534. 44 pp., illus.

Howalt, E. M. Soil defense of range and farm lands in the Southwest. Misc. Pub. 338. 52 pp., illus.

Welton, Kenneth. Saving soil with sod in the Ohio Valley region. Farmers' Bul. 1836. 29 pp., illus.

Whitfield, Charles J., and John A. Perrin. Sand-dune reclamation in the southern Great Plains. Farmers' Bul. 1825. 13 pp., illus.

1940

Allred, B. W. Range conservation practices for the Great Plains. Misc. Pub. 410. 21 pp., illus.

Chapline, W. R., F. G. Renner,* and Raymond Price. The new range outlook. In Farmers in a changing world, Yearbook of Agriculture 1940, pp. 441-457.

Schwendiman, John L., Roland F. Sackman, and A. L. Hafenrichter. Processing seed of grasses and other plants to remove awns and appendages. C. 558. 16 pp., illus.

U.S. Forest Service and U.S. Soil Conservation Service. Influences of vegetation and watershed treatments on run-off, silting, and stream flow. Misc. Pub. 397. 80 pp., illus.

1941

Graham, Edward H. Legumes for erosion control and wildlife. Misc. Pub. 412. 153 pp., illus.

McCorkle, J. S., and Tom Dale. Conservation practices for the range lands of the Southern Great Plains. Soil Conserv. Serv., Washington, D.C. 32 pp., illus., map.

1942

Flory, Evan L., and Charles G. Marshall. Regrassing for soil protection in the Southwest. Farmers' Bul. 1913. 60 pp., illus.

McLaughlin, Willard T. and Robert L. Brown. Controlling coastal sand dunes in the Pacific Northwest. C. 660. 46 pp., illus.

Renner, F. G., and E. A. Johnson. Improving range conditions for wartime livestock production. Farmers' Bul. 1921. 18 pp., illus.

Semple, A. T.,* H. N. Vinall, C. R. Enlow,* and T. E. Woodward. A pasture handbook, rev. (slightly revised again in 1946). Misc. Pub. 194. 88 pp., illus.

__________,* and M. A. Hein. Pastures to hold and enrich the soil. Farmers' Bul. 1900. 29 pp., illus. (Slightly revised 1945.)

1943

Alberts, H. W. and Ovidio Garcia-Molinari. Pastures of Puerto Rico and their relation to soil conservation. Misc. Pub. 513. 46 pp., illus.

Daniel, Harley A., Harry M. Elwell, and Maurice B. Cox. Investigations in erosion control and reclamation of eroded land at the Red Plains Conservation Experiment Station, Guthrie, Okla., 1930-40. Tech. Bul. 837. 94 pp., illus.

Semple, A. T.,* and M. A. Hein. Good pastures. Farmers' Bul. 1942. 22 pp., illus.

Various authors, including J. L. Lantow.* Range and livestock production practices in the Southwest. Misc. Pub. 529. 21 pp., illus. Prepared by an interagency group from the Department of Agriculture, Department of Interior, New Mexico College of Agriculture and Mechanic Arts, and the University of Arizona.

White, W. T., W. R. Frandsen, R. R. Humphrey, and N. T. Nelson. Food for freedom by better range-conservation practices in the Pacific Northwest. Misc. Pub. 514. 19 pp., illus.

1944

Copley, T. L., Luke A. Forrest, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded land at the Central Piedmont Conservation Experiment Station, Statesville, N.C., 1930-40. Tech. Bul. 873. 66 pp., illus.

Hill, H. O., W. J. Peevy, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded land at the Blackland Conservation Experiment Station, Temple, Tex., 1931-41. Tech. Bul. 859. 109 pp., illus.

Horner, Glenn M., A. G. McCall, and F. G. Bell. Investigations in erosion control and the reclamation of eroded land at the Palouse Conservation Experiment Station, Pullman, Wash., 1931-42. Tech. Bul. 860. 83 pp., illus.

1945

Borst, Harold L., A. G. McCall, and F. G. Bell. Investigations in erosion control and the reclamation of eroded land at the Northwest Appalachian Conservation Experiment Station, Zanesville, Ohio, 1934-42. Tech. Bul. 888. 95 pp., illus.

Hamilton, J. G., Grover F. Brown, Harold E. Tower, and Wilkie Collins Jr. Irrigated pastures for forage production and soil conservation. Farmers' Bul. 1973. 30 pp., illus.

Crider, Franklin J. Three introduced lovegrasses for soil conservation. C. 730. 90 pp., illus.

Smith, D. D., D. M. Whitt, Austin W. Zingg, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded Shelby and related soils at the Conservation Experiment Station, Bethany, Mo., 1930-42. Tech. Bul. 883. 175 pp., illus.

1946

Pieters, A. J. Legumes in soil conservation practices. L. 163. 8 pp., illus.

Pope, J. B., James C. Archer, P. R. Johnson, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded sandy clay lands of Texas, Arkansas, and Louisiana at the Conservation Experiment Station, Tyler, Tex., 1931-40. Tech. Bul. 916. 76 pp., illus.

1947

Hoover, Max M., James E. Smith Jr., A. E. Ferber, and D. R. Cornelius. Seed for regrassing Great Plains areas. Farmers' Bul. 1985. 37 pp., illus.

Ramser, C. E. Grass in farm waterways. In Science in farming, Yearbook of Agriculture 1943-1947, pp. 541-546.

Stillwater (Okla.) Outdoor Hydraulic Laboratory (Vernon J. Palmer and William P. Law, Jr.). Handbook of channel design for soil and water conservation. SCS-TP-61. 34 pp., illus.

1948

Allred, B. W., and Howard Matson. Spacing water holes to save grass. In Grass, Yearbook of Agriculture 1948, pp. 236-239.

Bailey, R. Y., and W. M. Nixon. Rotations for problem fields. In Grass, Yearbook of Agriculture 1948, pp. 195-199.

Browning, G. M., R. A. Norton, A. G. McCall, and F. G. Bell. Investigation in erosion control and the reclamation of eroded land at the Missouri Valley Loess Conservation Experiment Station, Clarinda, Iowa, 1931-42. Tech. Bul. 959. 88 pp., illus.

Campbell, R. S., Lincoln Ellison, and F. G. Renner.* Management that restores the range. In Grass, Yearbook of Agriculture 1948, pp. 221-226.

Coffman, E. B. Grass for conservation (in the Northeastern States). In Grass, Yearbook of Agriculture 1948, pp. 410-412.

Davison, Verne E. Bicolor lespedeza for quail and soil conservation in the Southeast. L. 248. 8 pp., illus.

Gardner, Harry H., and John P. Jones. Pasture in a conservation farm plan. In Grass, Yearbook of Agriculture 1948, pp. 154-160.

Hafenrichter, A. L., and A. D. Stoesz. Domesticated grasses in conservation. In Grass, Yearbook of Agriculture 1948, pp. 354-356, 753-758.

Hoover, Max M.,* M. A. Hein, William A. Dayton, and C. O. Erlanson. The main grasses for farm and home. In Grass, Yearbook of Agriculture 1948, pp. 639-700.

Savage, D. A.,* James E. Smith,* and D. F. Costello. Dry-land pastures on the Plains. In Grass, Yearbook of Agriculture 1948, pp. 506-522.

__________, and James E. Smith. The production of seed. In Grass, Yearbook of Agriculture 1948, pp. 537-540.

Uhland, R. E. Grass and the yields of cash crops. In Grass, Yearbook of Agriculture 1948, pp. 191-194.

White, W. T., W. R. Frandsen, and C. V. Jensen. Planning range conservation. In Grass, Yearbook of Agriculture 1948, pp. 217-221.

Whitfield, Charles J., and Robert L. Brown. Grasses that fix sand dunes. In Grass, Yearbook of Agriculture 1948, pp. 70-74.

Wolfolk, E. J., D. F. Costello, and B. W. Allred.* The major range types. In Grass, Yearbook of Agriculture 1948, pp. 205-211.

1949

Bailey, R. Y. Using tall fescue in soil conservation. L. 254. 8 pp., illus.

Hafenrichter, A. L., Lowell A. Mullen, and Robert L. Brown. Grasses and legumes for soil conservation in the Pacific Northwest. Misc. Pub. 678. 56 pp., illus.

Hays, O. E., A. G. McCall, and F. G. Bell. Investigations in erosion control and the reclamation of eroded land at the Upper Mississippi Valley Conservation Experiment Station near La Crosse, Wis., 1933-43. Tech. Bul. 973. 87 pp., illus.

Gardner, Harry H., and Edwin Freyburger. Grass waterways. L. 257. 8 pp., illus.

Uhland, R. E. The value of crop rotations for soil and water conservation. SCS-TP-83. 12 pp.

1950

Hays, Orville E. Some records of grassland farming in Wisconsin and Minnesota. SCS-TP-94. 9 pp.

Pieters, A. J.,* Paul R. Henson, William E. Adams, and A. P. Barnett.* Sericea and other perennial lespedezas for forage and soil conservation. C. 863. 48 pp., illus.

1951

Bailey, R. Y. Sericea in conservation farming. Farmers' Bul. 2033. 30 pp., illus.

Oman, Harry F., and Russell H. Stark. Grass seed production on irrigated land. L. 300. 8 pp., illus.

U.S. Soil Conservation Service. Soil Conservation promotes grassland farming. Soil Conserv. Serv., Washington, D.C. 24 pp., illus.

Wolff, Simon E. Harvesting and cleaning grass and legume seed in the western Gulf region. Agr. Hbk. 24. 106 pp., illus.

1952

Crider, Franklin J. Natob--a new bush lespedeza for soil conservation. C. 900. 10 pp., illus.

Miller, Arthur E., and Carroll H. Dwyer. Improved management of irrigated pastures pays dividends. PA-205. 8 pp., illus.

1953

Stallings, J. H. Continuous plant cover the key to soil and water conservation. SCS-TP-121. 17 pp., illus.

1954

Davison, Verne E. Lespedezas for quail and good land use. L. 373. 8 pp., illus.

Greene, E. H., and E. A. Hodson. Planning and managing tame pastures in soil conservation. Soil Conserv. Serv., Washington, D.C. 40 pp., illus.

McCorkle, J. S. Grass--the rancher's crop. L. 346. 8 pp., illus.

McPherron, E. L. Birdsfoot trefoil in Minnesota. U.S. Dept. Agr., SCS-TP-122. 13 pp., illus.

1955

Allred, B. W. and W. M. Nixon. Grass for conservation in the southern Great Plains. Farmers' Bul. 2093. 30 pp., illus.

Crider, Franklin J. Root-growth stoppage resulting from defoliation of grass. Tech. Bul. 1102. 23 pp., illus.

Dale, Tom, and Grover F. Brown. Grass crops in conservation farming. Farmers' Bul. 2080. 22 pp., illus.

McWilliams, Jesse L. Effects of some cultural practices on grass production at Mandan, North Dakota. Tech. Bul. 1097. 28 pp., illus.

Renner, F. G.,* and L. D. Love. Management of water on western rangelands. In Water, Yearbook of Agriculture 1955, pp. 415-423.

Williams, Robert E. Development and improvement of coastal marsh ranges. In Water, Yearbook of Agriculture 1955, pp. 444-450.

1957

Cooper, H. W., James E. Smith, Jr., and M. D. Atkins. Producing and harvesting grass seed in the Great Plains. Farmers' Bul. 2112. 30 pp., illus.

Hafenrichter, A. L. Management to increase forage production in the West. SCS-TP-128. 16 pp., illus.

1960

Atkins, M. Donald. Grass waterways in soil conservation. L. 477. 8 pp., illus.

Frandsen, Waldo R. Grass makes its own food. Agr. Inf. Bul. 223. (Folder.)

Hawk, Virgil B. Birdsfoot trefoil seed production. U.S. Dept. Agr. SCS-TP-137. 12 pp., illus.

1961

Harmond, Jesse E., James E. Smith Jr.* and Joseph K. Park. Harvesting the seeds of grasses and legumes. In Seeds, Yearbook of Agriculture 1961, pp. 181-188.

Klein, Leonard M., James Henderson, Abraham D. Stoesz.* Equipment for cleaning seeds. In Seeds, Yearbook of Agriculture 1961, pp. 307-321.

Rogler, George A., Henry H. Rampton, and M. D. Atkins.* The production of grass seeds. In Seeds, Yearbook of Agriculture 1961, pp. 163-171.

Schwendiman, J. L., Donald S. Douglas, and A. L. Hafenrichter. Latar orchardgrass for conservation in the West. Prod. Res. Rept. 54. 8 pp., illus.

1962

Renner, F. G., and B. W. Allred. Classifying rangeland for conservation planning. Agr. Hbk. 235. 48 pp., illus.

*Soil Conservation Service coauthor.

## Selected Technical Articles and Bulletins Published Outside USDA

Listed here are some technical journal articles and State bulletins that give further information on the grassland revolution or that document the facts presented. Much of the SCS work was done jointly with workers in other agencies or in land grant colleges or State experiment stations. Only those publications that have an SCS author are listed; if there are non-SCS coauthors, the SCS author's name is followed by an asterisk. Some of the SCS authors are no longer with SCS, but they were at the time the work was done.


Allan, Philip F. 1950. Ecological bases for land use planning in Gulf Coast marshlands. J. Soil and Water Conserv. 5: 57-62, 85.

Allred, B. W. 1941. Grasshoppers and their effect on sagebrush on the Little Powder River in Montana and Wyoming. Ecol. 22: 387-392, illus.

__________ 1945. Some conditions and influences pertaining to the native forage crop of the northern mixed prairie. Agron. J. 37: 876-887, illus.

__________ 1949. Distribution and control of several woody plants in Texas and Oklahoma. J. Range Mangt. 2: 17-29.

Anderson, Darwin,* L. P. Hamilton,* H. G. Reynolds, and Robert R. Humphrey. 1957. Reseeding desert grassland ranges in southern Arizona. Ariz. Agr. Expt. Sta. Bul. 249, 32 pp.

__________, and A. R. Swanson. 1949. Machinery for seedbed preparation and seeding on southwestern ranges. J. Range Mangt. 2: 64-66.

Atkins, M. D. 1958. Cover on watershed dams. J. Soil and Water Conserv. 13: 220-222.

__________ 1962. Conservation plant materials for the Great Plains. J. Soil and Water Conserv. 17: 199-203.

Atkins, Oxell A., and W. C. Young. 1941. The partridge pea, Chamaecrista fasciculata, a promising plant for soil conservation. Agron. J. 33: 471-472.

Barnes, O. K. 1950. Mechanical treatments on Wyoming range land. J. Range Mangt. 3: 198-203.

Bennett, H. H. 1935. Relation of grass cover to erosion control. Agron. J. 27: 173-179.

Brown, Robert L., and A. L. Hafenrichter. 1948. Factors influencing the production and use of beachgrass and dunegrass clones for erosion control: I. Effect of date of planting. Agron. J. 40: 512-521.

__________, and A. L. Hafenrichter. 1948. Factors influencing the production and use of beachgrass and dunegrass clones for erosion control: II. Influence of density of planting. Agron. J. 40: 603-609.

__________, and A. L. Hafenrichter. 1948. Factors influencing the production and use of beachgrass and dunegrass clones for erosion control: III. Influence of kinds and amounts of fertilizer on production. Agron. J. 40: 677-684.

Browning, G. M., C. L. Parish, and John Glass. 1947. A method for determining the use and limitations of rotations and conservation practices in the control of soil erosion in Iowa. Agron. J. 39:65-73.

Carlson, Norman K. 1952. Three grasses' struggle for supremacy on Island of Molokai. J. Range Mangt. 5: 8-12.

__________, 1952. Grazing land problems, Molokai Island, Territory of Hawaii. J. Range Mangt. 5: 230-242.

Chapin, W. E.,* A. L. Hafenrichter,* and A. G. Law. 1951. Performance of strains of Lotus corniculatus on the north Pacific coast. Agron. J. 43: 438-442.

__________, A. G. Law, and A. L. Hafenrichter.* 1955. Pasture mixtures for upland soils in northwest Washington. Wash. Agr. Expt. Sta. C. 260, 13 pp.

Chohlis, G. John. 1952. Range condition in eastern Washington fifty years ago and now. J. Range Mangt. 5: 129-134.

__________, and Fred Schlots. 1950. Range condition and soil site classification by helicopter. J. Range Mangt. 3: 114-117.

Cooper, Harold W. 1953. Amounts of big sagebrush in plant communities near Tensleep, Wyoming, as affected by grazing treatment. Ecol. 34: 186-189, illus.

__________, 1957. Some plant materials and improved techniques used in soil and water conservation in the Great Plains. J. Soil and Water Conserv. 12: 163-168.

Cornelius, Donald R. 1944. Revegetation in the tall grass prairie region. Agron. J. 36: 393-400.

__________ 1946. Comparison of some soil-conserving grasses. Agron. J. 38: 682-689.

__________ 1946. Establishment of some true prairie species following seeding. Ecol. 27: 1-12.

__________ 1947. The effect of source of little bluestem grass seed on growth, adaptation, and use in revegetation seedings. J. Agr. Res. 74: 133-143.

__________ 1950. Seed production of native grasses under cultivation in eastern Kansas. Ecol. Monog. 20: 1-29.

__________, and M. D. Atkins. 1946. Grass establishment and development studies in Morton County, Kansas. Ecol. 27: 342-353.

Davison, Verne E. 1945. Wildlife values of the lespedezas. J. Wildlife Mangt. 9: 1-9.

Douglas, D. S.,* and R. D. Ensign. 1954. Sodar wheatgrass. Idaho Agr. Expt. Sta. Bul. 234, 4 pp.

__________,* A. L. Hafenrichter,* and K. H. Klages. 1960. Cultural methods and their relation to establishment of native and exotic grasses in range seedings. J. Range Mangt. 13: 53-57.

Dyksterhuis, E. J. 1945. Axillary cleistogenes in Stipa leucotricha and their role in nature. Ecol. 26: 195-199, illus.

__________ 1949. Condition and management of range land based on quantitative ecology. J. Range Mangt. 2: 104-115.

__________ 1953. Determining the condition and trend of ranges (natural pastures). Proc. 6th Interni. Grassland Cong., 1322-1327.

__________ 1957. The savannah concept and its use. Ecol. 38: 435-442, illus.

__________ 1958. Ecological principles in range evaluation. Bot. Rev. 24: 253-272.

Elwell, Harry M., and Maurice B. Cox. 1950. New methods of brush control for more grass. J. Range Mangt. 3: 46-51.

Ensminger, M. E., H. G. McDonald, A. L. Law, E. J. Warwick, E. J. Kreisinger, and V. B. Hawk.* 1944. Grass and grass-alfalfa mixtures for beef production in eastern Washington. Wash. Agr. Expt. Sta. Bul. 444, 24 pp.

Frandsen, Waldo R. 1950. Management of reseeded ranges. J. Range Mangt. 3: 125-129.

Fults, Jess L. 1942. Somatic chromosome complements in bouteloua. Amer. J. Bot. 29: 45-55.

Galgan, M. W., M. E. Ensminger, D. E. Foster, W. E. Ham, B. H. Schneider, J. L. Schwendiman,* I. R. Adlard,* and J. K. Patterson. 1953. Grass and grass-alfalfa pastures supplemented with silage or grain for beef production in eastern Washington. Wash. Agr. Expt. Sta. C. 233, 5 pp.

Gamble, M. D.,* and Edd D. Rhoades. 1964. Effect of shoreline fluctuations on grasses associated with upstream flood prevention and watershed protection. Agron. J. 56: 21-23.

Garnder, J. L. 1951. Vegetation of the creosotebush area of the Rio Grande valley in New Mexico. Ecol. Monog. 21: 379-403, illus.

__________, and D. S. Hubbell. 1943. Some vegetational responses after eight years of protection from grazing. Ecol. 24: 409-410.

Grest, Edward G. 1953. The range story of the land utilization projects. J. Range Mangt. 6: 44-50.

Hafenrichter, A. L. 1948. Getting new range plants into practice. J. Range Mangt. 1: 9-18.

__________ 1952. Factors that affect the choice of grasses used with legumes for soil conservation. Proc. 6th Internatl. Grassland Cong., 962-967.

__________ 1956. Improving pastures on lands in difficult environments in the Western United States. Proc. 7th Internatl. Grassland Cong., 498-508.

__________ 1958. New grasses and legumes for soil and water conservation. Advn. Agron. 10: 349-406.

Halliday, Blaine O. 1957. Nineteen years of range improvement on the Crystal Springs Range Demonstration Area in Nevada. J. Range Mangt. 10: 203-207.

Hawk, V. B.,* H. D. Hughes, and F. W. Schaller. 1954. Reed canarygrass heals gullies. J. Soil and Water Conserv. 9: 203-210.

__________, and Aaron W. Welch. 1948. Tolerance of varieties of smooth bromegrass, Bromus inermis leyss., to injury by root rot, Pythium graminicola subr. Agron. J. 40: 809-817.

Heerwagen, Arnold. 1955. The effect of grazing use upon ponderosa pine reproduction in the Rocky

Mountain area. Proc. Soc. Amer. For. 206-207.

Heerwagen, Arnold. 1959. Improving range resources through management. In Grasslands. Amer. Assoc. Advn. Sci., Pub. 53, 391-401.

__________, and Andrew R. Aandahl. 1961. Utility of soil classification units in characterizing native grassland plant communities in the Southern Plains. J. Range Mangt. 14: 207-213.

Hoglund, O. K., H. W. Miller, and A. L. Hafenrichter. 1952. Application of fertilizers to aid conservation on annual forage range. J. Range Mangt. 5: 55-61.

Hubbell, D. S., and J. L. Gardner. 1944. Some edaphic and ecological effects of water spreading on range lands. Ecol. 25: 27-44.

Humphrey, R. R. 1940. The use of forage-acre requirements in range surveys. Agron. J. 32: 754-760.

__________ 1945. Some fundamentals of the classification of range condition. J. For. 43: 646-647, illus.

__________, and P. B. Lister. 1941. Native vegetation as a criterion for determining correct range management and run-off characteristics of grazing lands. J. For. 39: 837-842, illus.

Larson, Floyd. 1940. The role of the bison in maintaining the short grass plains. Ecol. 21: 113-121.

Lemmon, Paul E., and A. L. Hafenrichter. 1947. The dilution method for plot or field seeding of grasses and legumes alone or in mixtures. Agron. J. 39: 817-821.

__________,* A. L. Hafenrichter,* and B. A. Madson. 1950. Cucamonga brome--a new grass for cover cropping. Calif. Agr. Expt. Sta. C. 401, 8 pp.

Lister, P. B. 1941. Fire control on grass ranges of the Pacific Northwest. J. For. 39: 23-25, illus.

Lommasson, T., and Chandler Jensen. 1943. Determining utilization of range grasses from height-weight tables. J. For. 41: 589-593, illus.

McIlvanie, S. K. 1942. Carbohydrate and nitrogen trends in bluebunch wheatgrass, Agropyron spicatum, with special reference to grazing influences. Plant Physiol. 17: 540-557, illus.

__________ 1942. Grass seedling establishment and productivity--overgrazed vs. protected range soils. Ecol. 23: 228-231, illus.

McWilliams, Jesse L., and Phillip E. Van Cleave. 1960. A comparison of crested wheatgrass and native grass mixtures seeded on rangeland in eastern Montana. J. Range Mangt. 13: 91-94.

Miller, H. W., A. L. Hafenrichter, and O. K. Hoglund. 1957. The influence of management methods on seedings of perennials in the annual range area. J. Range Mangt. 10: 62-66.

__________, O. K. Hoglund, and A. L. Hafenrichter. 1953. Reseeding to aid conservation of annual forage range. J. Range Mangt. 6: 414-422.

__________, O. K. Hoglund, and A. L. Hafenrichter. 1959. Grasses, legumes, and cultural methods for improving pasture production and aiding conservation on saline-alkali land. Calif. Dept. Natl. Res. Bul. 1, 24 pp.

Nielson, A. B. 1940. Management--a cure for overgrazed range. Agron. J. 32: 602-606.

Osborn, Ben. 1950. Some effects of the 1946-48 drought on ranges in southwest Texas. J. Range Mangt. 3: 1-15.

__________, and Philip F. Allan. 1949. Vegetation of an abandoned prairie-dog town in tall grass prairie. Ecol. 30: 322-332.

Parker, John M., and Charles J. Whitfield. 1941. Ecological relationships of playa lakes in the southern Great Plains. Agron. J. 33: 125-129, illus.

Passey, H. B., and V. K. Hugie. 1962. Application of soil-climate-vegetation relations to soil survey interpretations for rangelands. J. Range Mangt. 15: 162-166.

__________, and V. K. Hugie. 1952. Sagebrush on relict ranges in the Snake River plains and northern Great Basin. J. Range Mangt. 15: 273-278.

Pierre, J. J.,* and J. A. Jackobs. 1953. The effect of cutting treatments on birdsfoot trefoil. Agron. J. 45: 463-468.

__________,* and J. A. Jackobs. 1954. Growing birdsfoot trefoil in Illinois. Univ. of Ill., College of Agr., C. 725, 16 pp.

__________,* and G. D. Mott. 1948. Bromegrass strains in Indiana. Purdue Agr. Expt. Sta. C. 348, 7 pp.

Porterfield, Hugh G. 1944. A native grass seeder. Agron. J. 36: 630-635.

Ray, Hurlon C. 1958. Aerial chemical reduction of hardwood brush as a range improvement practice in Arkansas. J. Range Mangt. 11: 284, 286-290.

Renner, F. G. 1953. Experimental studies of natural grazing lands of the U.S. Proc. 7th Internl. Bot. Cong. 243-244.

Richards, D. E., and V. B. Hawk.* 1945. Palatability for sheep and yield of hay and pasture grasses at Union, Oregon. Oreg. Agr. Expt. Sta. Bul. 431, 51 pp.

Schwendiman, J. L. 1959. Testing new range forage plants. In Grasslands (Howard B. Sprague, ed.). Amer. Assoc. Adv. Sci., Pub. 53, 345-357.

__________,* A. L. Hafenrichter,* and A. G. Law. 1953. The production of tops and roots by grass and sweetclover when grown in mixtures. Agron. J. 45: 110-114.

Spence, Liter E. 1937. Root studies of important range plants of the Boise River watershed. J. For. 35: 747-754, illus.

Stark, R. H.,* A. L. Hafenrichter,* and K. H. Klages. 1949. The production of seed and forage by mountain brome as influenced by nitrogen and age of stand. Agron. J. 41: 508-512.

__________,* A. L. Hafenrichter,* and W. A. Moss. 1950. Adaptation of grasses for soil and water conservation at high altitudes. Agron. J. 42: 124-127.

Stark, R. H.* and K. H. Klages. 1949. Manchar smooth brome. Idaho Agr. Expt. Sta. Bul. 275, 6 pp.

__________,* J. L. Toevs, and A. L. Hafenrichter.* 1946. Grasses and cultural methods for reseeding abandoned farm lands in southern Idaho. Idaho Agr. Expt. Sta. Bul. 267, 36 pp.

__________,* J. L. Toevs, and A. L. Hafenrichter.* 1947. How to reseed abandoned land for pasture and range in southern Idaho. Idaho Agr. Expt. Sta. C. 112, 4 pp.

Stoesz, A. D. 1952. Harvesting, processing, and seeding of native grasses in the central and northern Great Plains. Agron. J. 44: 378-383, illus.

__________, and J. E. Smith, Jr. 1952. The techniques of harvesting and processing native grass seed. Proc. 6th Internl. Grassland Cong., 1671-1676.

Tabor, Paul. 1962. Permanent plant cover for road cuts and similar conditions by secondary succession. Agron. J. 54: 179.

Tatcher, Albert P. 1959. Distribution of sagebrush as related to site differences in Albany County, Wyoming. J. Range Mangt. 12: 55-61.

Weber, G. L. 1939. A method of preparing some native grass seeds for handling and seeding. Agron. J. 31: 729-733, illus.

Welton, Kenneth. 1960. Introduction of new plant materials in the Corn Belt States. J. Soil and Water Conserv. 15: 162-166, 205-209.

Whitfield, Charles J.,* and Hugh L. Anderson. 1938. Secondary succession in the desert plains grassland. Ecol. 19: 171-180, illus.

__________, and Edward L. Beutner. 1938. Natural vegetation on the desert plains grassland. Ecol. 19: 26-37.

__________,* and C. L. Fly. 1939. Vegetational changes as a result of furrowing on pasture and range lands. Agron. J. 31: 413-417, illus.

Williams, Robert E. 1952. Better management on longleaf pine forest ranges. J. Range Mangt. 5: 135-140.

Woods, J. E.,* A. L. Hafenrichter,* J. L. Schwendiman,* and A. G. Law. 1953. The effect of grasses on yield of forage and production of roots by alfalfa-grass mixtures with special reference to soil conservation. Agron. J. 45: 590-595.

## LIST OF PLANT NAMES

Listed here is the botanical name along with the variety name and the species common name of each of the grasses and legumes that are mentioned in this publication.

| Species common name | Variety name | Botanical name |
|---|---|---|
| alfalfa | Ranger | Medicago sativa |
| bahiagrass | Common, Argentine, Paraguay 22, Pensacola | Paspalum notatum |
| beachgrass, European | | Ammophila arenaria |
| bean, velvet | | See velvetbean |
| bermudagrass | Coastal | Cynodon dactylon |
| bluegrass, big | Sherman | Poa ampla |
| bluegrass, Canada | | Poa compressa |
| bluegrass, Kentucky | | Poa pratensis |
| bluestem, big | | Andropogon gerardi |
| bluestem, little | | Andropogon scoparius |
| bluestem, yellow | King Ranch | Andropogon ischaemum |
| bristlegrass, plains | Odessa | Setaria machrostachya |
| brome, California | Cucamonga | Bromus carinatus |
| brome, field | Svalofs Sleipner | Bromus arvensis |
| brome, mountain | Bromar | Bromus marginatus |
| brome, smooth | Achenbach, Elsberry, Fischer, Lincoln, Manchar | Bromus inermis |
| buffalograss | | Buchloe dactyloides |
| buffelgrass | | Pennisetum ciliare |
| canarygrass, reed | Ioreed | Phalaris arundinacea |
| carpetgrass, common | | Axonopus affinis |
| chess, soft | Blando | Bromus mollis |
| clover, alsike | | Trifolium hybridum |
| clover, ball | | Trifolium nigrescens |
| clover, crimson | | Trifolium incarnatum |
| clover, kaimi (see kaimiclover) | | |
| clover, mike | | Trifolium michelianum |
| clover, red | | Trifolium pratense |
| clover, sweet (see sweetclover) | | |
| clover, white | Ladino | Trifolium repens |
| cowpea | | Vigna sinensis |
| crownvetch | Chemung, Emerald | Coronilla varia |
| dallisgrass | | Paspalum dilatatum |
| fescue, tall | Kentucky 31, Goar | Festuca arundinacea |
| foxtail, creeping | Garrison | Alopecurus arundinaceus |
| gamagrass, eastern | | Tripsacum dactyloides |
| grama, black | | Bouteloua eriopoda |
| grama, blue | | Bouteloua gracilis |
| grama, sideoats | Coronado, El Reno, Pierre, Uvalde, Vaughn | Bouteloua curtipendula |
| guineagrass, slender | | Panicum maximum var. pubiglume |
| hardinggrass | | Phalaris tuberosa var. stenoptera |
| indiangrass | Cheyenne | Sorghastrum nutans |
| indigo, hairy | | Indigofera hirsuta |

| Species common name | Variety name | Botanical name |
|---|---|---|
| johnsongrass | | Sorghum halepense |
| kaimiclover | | Desmodium canum |
| kikuyugrass | | Pennisetum clandestinum |
| kudzu | | Pueraria thunbergiana |
| lespedeza, Japan | | Lespedeza japonica |
| lespedeza, sericea | | Lespedeza cuneata |
| lespedeza, shrub | | Lespedeza bicolor |
| lespedeza, striate (common) | Common, Kobe | Lespedeza striata |
| lovegrass, Boer | | Eragrostis chloromelas |
| lovegrass, Lehmann | | Eragrostis lehmanniana |
| lovegrass, weeping | | Eragrostis curvula |
| needlegrass, green | | Stipa viridula |
| orchardgrass | Latar | Dactylis glomerata |
| pangolagrass | | Digitaria decumbens |
| panicgrass, blue | | Panicum antidotale |
| paspalum | | Paspalum spp. |
| pea, field | Austrian Winter | Pisum sativum, var. arvense |
| redtop | | Agrostis alba |
| ryegrass | | Lolium spp. |
| sacaton, Wright's | | Sporobolus wrightii |
| sacaton, alkali | Willcox | Sporobolus airoides |
| sorghum | | Sorghum vulgare |
| sprangeltop, green | Marfa | Leptochloa dubia |
| sudangrass | | Sorghum sudanense |
| sweetclover, white | | Melilotus alba |
| sweetclover, yellow | | Melilotus officinalis |
| switchgrass | Blackwell, Grenville | Panicum virgatum |
| timothy | | Phleum pratense |
| trefoil, birdsfoot | Empire | Lotus corniculatus |
| trefoil, big | | Lotus uliginosus |
| trefoil, narrowleaf birdsfoot | Los Banos | Lotus tenuis |
| trichloris, fourflowered | | Trichloris pluriflora |
| trichloris, twoflowered | | Trichloris crinita |
| velvetbean | | Stizolobium spp. |
| vetch, common | | Vicia sativa |
| vetch, hairy | | Vicia villosa |
| vetch, woollypod | Lana | Vicia dasycarpa |
| wheatgrass, beardless | Whitmar | Agropyron inerme |
| wheatgrass, bluebunch | | Agropyron spicatum |
| wheatgrass, crested | | Agropyron desertorum |
| wheatgrass, intermediate | Greenar | Agropyron intermedium |
| wheatgrass, pubescent | Topar | Agropyron trichophorum |
| wheatgrass, Siberian | | Agropyron sibiricum |
| wheatgrass, slender | Primar | Agropyron trachycaulum |
| wheatgrass, streambank | Sodar | Agropyron riparium |
| wheatgrass, tall | Alkar, Largo | Agropyron elongatum |
| wheatgrass, western | | Agropyron smithii |
| wildrye, basin | | Elymus cinereus |
| wildrye, Canada | Mandan | Elymus canadensis |
| wildrye, giant | | Elymus condensatus |
| wildrye, Russian | | Elymus junceus |



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